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BIOLOGY AND MORPHOLOGY OF LEPYRONIA QUADRANGULARIS (Say)—HOMOPTERA, CERCOPIDÆ.....*Kathleen Doering.*

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Biology and Morphology of *Lepyronia quadrangularis* (Say)—Homoptera, Cercopidæ.

BY KATHLEEN DOERING.

Submitted to the Department of Entomology, University of Kansas, in partial fulfillment of the requirements for the degree of Master of Arts.

INTRODUCTION.

THE purpose of this paper is twofold; first to add to the limited data concerning the biology of the Cercopidæ; and secondly, to contribute to the morphological knowledge of the family, and incidentally of the order. The subject of this paper was suggested by Dr. Paul B. Lawson. Since *Lepyronia quadrangularis* (Say) is one of our most common spittle bugs, it was thought that a study of its biology, habits and morphology would be well worth while. Later when a review of the literature revealed the meagerness of both biological and morphological details concerning other species in the family, the necessity for this work was magnified.

By means of the morphological studies the writer has attempted to accomplish two things: First, since little work has been done on the morphology of any cercopid, to give a detailed description of the external anatomy, merely for the morphological interest involved; and secondly, to contribute a small share, if possible, in determining the relationships of the families within the order. A thorough knowledge of the morphology of all families in a given order seems necessary to correctly determine their phylogenetic relationship. In the literature, however, they are usually determined on the basis of a comparison of certain special parts of the body of a single species from each family. But since the species, or at least the genera, may vary within a family, some having primitive head sclerites and specialized genitalia, while others are just the opposite, it follows that a fairly thorough knowledge of the entire structure of the body

should be obtained before such relationships are determined. To this end this small contribution is made.

The writer wishes to express her appreciation to all who have assisted in this work: To Prof. S. J. Hunter for his interest and readiness to help; to Dr. Paul B. Lawson, under whose direction the work was done, and who, at the sacrifice of his own research time, gave most helpful advice and criticism; to Dr. Grace M. Charles for the correct identification of most of the host plants; to Lucy M. Hackman, Dr. H. B. Hungerford and P. A. Readio for their kindly help and criticism, and to all others who in any way have assisted in this work.

THE SYSTEMATIC POSITION.

FAMILY CHARACTERISTICS.

The Cercopidæ are distinguished from the other families of Homoptera by having three-segmented tarsus, two ocelli, the antennæ inserted in front of and between the eyes; the prothorax not prolonged backward, and the hind tibiæ armed with one or two stout teeth, with two rows of short, stout spines at the tip.

SUBFAMILY CHARACTERISTICS.

The Cercopidæ are divided into two subfamilies—Cercopinæ Am. & Serville, and Aphrophorinæ Am. & Serv. *Lepyronia quadrangularis* (Say) comes within the latter. According to Ball (1898) the Aphrophorinæ are separated from the Cercopinæ by the following characteristics: Anterior margin of the pronotum angulate; head equaling or almost equaling the pronotum in width; elytra compressed behind, rarely reticulate.

HISTORICAL REVIEW.

This insect has been described under various genera. It was first made known to science by Say in 1825 as *Cercopis quadrangularis*. In 1831 is was put in the genus *Aphrophora* by Say, and in 1851 in the genus *Ptyelus* by Walker. Amyot and Serville (1843) described it under the genus *Lepyronia,* which name it now holds.

GENERIC DESCRIPTION.

The original description of the genus by Amyot and Serville is as follows: "Corps court et remassé. Tête en cône arrendi antérieurement, sans caréne longitudinale médiane sur le vertex ni sur le front. Elytres bombées, en ovale court et en forme de coquille. Les autres caractéres sont ceux des *Aphrophores.* Du gree λεπυρδγ, coquille d'œuf."

The genus *Leypronia* is separated by Ball from the other genera of Aphrophorinæ by these characteristics: Anterior margin of vertex between front and eyes sharp; ocelli nearly equally distant from eyes and each other; rostrum short, not exceeding middle coxæ; anterior margin of pronotum rounded; corium without terminal membrane; whole upper surface densely pubescent, hiding sculpturing and venation.

KEY TO SPECIES.*

A. Margins of the vertex regularly rounding to the obtuse tip; elytra slightly angularly inflated, nearly twice longer than their combined width (folded), grayish, testaceous, with a distinct V on each elytron. *quadrangularis* (Say).

AA. Margins of vertex straight or concave, the tip slightly produced; elytra inflated, no more than one-half longer than their combined width (folded).

B. Small, testaceous, rather narrow; the vertex broad and short, shorter or only equaling the pronotum in length; apex of elytra broadly subhyaline. *angulifera* (Uhl).

BB. Large, nearly uniform grayish, general form globose; vertex longer than pronotum. *gibbosa* (Ball).

The original description of Say is given herewith:

Brownish-cinereous elytra with two oblique brown bands confluent at the outer margin; beneath black; feet annulate with pale. Body brownish cinereous, covered with dense, minute hairs; head obsoletely spotted; eyes fuscous, a pale longitudinal line on the middle, in which is a brown central line; stemmata indistinct, black; thorax emarginate at the anterior angles for the reception of the eyes, and deeply emarginate behind for the reception of the scutel; a double series of obsolete, indented spots before; scutel, tip and basal angles acute; hemelytra pale brownish cinereous; an oblique black-brown fascia from inner basal angle is confluent at the middle of the exterior margin, with an oblique fascia, which terminates near the sutural tip; tip with a small blackish curve; region of humerus dusky, beneath black; feet black; thighs annulate with pale; posterior pair of tibiæ pale, armed with two robust spines behind and numerous small ones at the tip; posterior tarsi armed with spinules at the tips of the first and second joints beneath; abdomen black; tail pale beneath.

The following is a technical description:

Form. Length: ♀ 6.4 to 7.2 mm.; ♂ 6 to 6.8 mm. Width: ♀ 3 to 3.2 mm.; ♂ 2.4 to 3 mm.

Vertex flat or depressed; length and width about equal, as long as pronotum, margins rounding to a blunt apex; tylus large, parallel margined, nearly one-half length of vertex; eyes level with vertex, distended below; front somewhat inflated, rising gradually from the sides, margins convex, slightly longer than wide; clypeus only slightly inflated, twice as long as wide; pronotum flat, twice as wide as long, slightly emarginate anteriorly with transverse rows of im-

*Ball, E. D. A Review of the Cereopidæ of North America North of Mexico. Rept. Ia. Acad. Science, 1898.

pressions behind margins; lateral margins nearly parallel, longer than short diameter of eye; elytra not quite twice as long as wide, outer margin flaring, apex angulate; abdomen broadly triangular, about as wide as long, margins and apex greatly exceeded by wings.

Color. Vertex and tylus mottled testaceous brown; minute yellow line on margins; eyes deep fuscous; face uniform testaceous brown; pronotum reddish brown at base, fading into brown cinerous; elytra grayish or tawny brown, a patch at the base, another at apex, an oblique band from tip of scutellum to a point beyond middle of costa, another from point of claws, meeting this on costa and forming a V on each elytron, brownish fuscous; abdomen blackish brown, apex paler; legs testaceous brown, annulate with pale, spines on posterior leg very black at tips.

LIFE HISTORY.

HISTORY.

Life history notes on the Cercopidæ are rather limited. Osborn (1916) made some valuable studies of the life histories of Maine froghoppers, but gave no complete history, including the egg stage and five nymphal stages, of any one species. He figures and describes three instars of *Lepyronia quadrangularis*. In 1921 Garman published the life history of *Philænus lineatus* (Linn.), wherein he describes the egg and four instars. Later Barber and Ellis (1922) described the oviposition of three species, *Philænus lineatus* (Linn.) and *Philaronia bilineata* (Say.) The most complete study of a cercopid life history is that of a foreign form, *Tomaspis varia*, which is a pest of sugar cane in Trinidad (Urich, 1913). Garman (1923) gives a complete description of the life history of *Clastoptera obtusa* (Say) and a brief description of the egg stage of *Lepyronia quadrangularis* (Say).

DISTRIBUTION.

Lepyronia quadrangularis (Say), according to the Snow collection, has been taken from four counties in Kansas, namely, Cherokee, Douglas, Neosho, and Doniphan. It is also recorded here from Atherton, Mo. Ball (1898) lists it from Ontario, New Hampshire, New York, Pennsylvania, Connecticut, District of Columbia, Maryland, West Virginia, Georgia, Florida, Mississippi, Ohio, Iowa, South Dakota, Nebraska, Colorado and Texas. Van Duzee lists it from Muskoka lake district of Canada, Lake Temagami, Ontario and Quinze lake region. Comstock says it is one of the most common spittle bugs of eastern United States.

HABITAT.

Lepyronia quadrangularis is usually associated with weed patches, and therefore might truly be called a weed insect. Yet its habitat is not quite so general as this would imply. Neither adults nor nymphs can be taken on every weed patch one runs across in collecting, but seems to be found only in particular places. The selected spots usually occur near woods or thickets. It has been taken in thickets where weeds have sprung up in open spaces, by the roadsides adjoining woods or thickets, and on the weeds growing at the edge of a wheat field and on the wheat itself. They were found in most abundance, however, in a weed patch occupying half of a city block. This plot offered a variety of host plants and shelter, such as dogwood and elm sprouts, and large patches of sweet-clover, ragweed and grasses; in fact, most of the collecting necessary for this work was done at this place, and several thousands of spittle insects must have been taken here.

HIBERNATION AND SPRING APPEARANCE.

Ball (1920) stated that all Cercopidæ except one overwinter in the egg stage. Having this idea in mind when these studies were started, it was expected that the adults soon after emerging would mate, the female lay her eggs, and the overwintering form be easily obtained. The matter, however, was not as simple as this. During the summer of 1921 adults were observed in the field until August, but no mating or oviposition took place. The following spring, toward the latter part of April, eggs were sought in the field, but none could be found. On April 29 the first instars were found. At this time Mr. C. H. Curran gave the writer two adult females which he had collected on April 1 and April 4. He stated that toward the latter part of March and April adults had been quite abundant. This evidence seemed to point to the supposition that the adults might overwinter. Throughout the summer adults were closely observed in both the field and laboratory. During August and September adults were very abundant, an average of fifty being taken in an hour's collecting. On September 27, seventy-five adults were taken; on October 9, sixty; and October 19, thirty. In one of the outside cages four adults were observed on November 23. These late occurrences were due, no doubt, to the very late season, which prolonged vegetation as well as insect life.

In the late fall, after mating had taken place, an experiment was attempted for the purpose of obtaining a premature oviposition.

Twenty adults were placed in a glass jar containing sterilized leaves and twigs and covered by cheese cloth. The jar was then placed outdoors, surrounded by ice except for a small breathing space at the top and kept in this condition for eight days. After a few days the adults became very sluggish, scarcely moving when disturbed except for a slight motion of the legs. When the eight days had elapsed they were brought into a warm room and placed in a cage in which green plants were growing. Nine out of twenty insects survived, but no oviposition occurred. Although not fulfilling its original purpose, the experiment seemed to show that the adults probably overwinter. On December 23 Mr. Beamer collected a female of this species while sifting leaves in Cherokee county. Four overwintering females were taken on April 18 and 19 of this year. The exact place of hibernation is difficult to determine. To date no adults have been obtained from the outside cage. They probably overwinter deep down under the leaves and matted grass in the cracks and crevices of the ground.

CLIMATOLOGICAL DATA.

As was stated in the foregoing paragraphs, overwintering females were taken on April 1 and April 4 in the spring of 1922, and perhaps others could have been obtained earlier, while in 1923 the first ones were taken on April 19, making a total difference of seventeen days. This great variation can easily be explained by the difference in temperature of the two years. A comparison of the two springs is given in the following table:

	Mean for month.	*Departure from normal.*	*Lowest temperature.*	*Highest temperature.*	*Greatest daily range.*
1922.					
February	34.2°	+1.47	2° on 13th	75° on 21st	39°
March	44.5°	+1.4	10° on 1st	78° on 23d	36°
April	56.3°	+1.7	31° on 1st	82° on 6th	38°
1923.					
February	30.3°	—0.54	—2°	61°	38°
March	40.74°	—2.03	—1°	80°	44°

From a study of the table it is readily seen that the spring of 1922 was above normal, while this spring is below normal, which accounts for the great difference in the dates of spring emergence.

SEASONAL HISTORY AND SUMMARY OF LIFE HISTORY.

A brief seasonal history and summary of life history is as follows: The insect spends the greater part of the year in the adult form, covering a period of about ten months, and the other two months are spent in the egg and nymphal stages. Mating takes place in the fall; the females overwinter, emerging in the spring along in April. A few days after emergence the eggs are laid.

The egg stage probably lasts two weeks, followed by a six weeks' nymphal stage. The adults appear in June and feed all summer and fall until after mating, when the males probably die and the females go into winter quarters.

OVIPOSITION.

Females collected in the spring were confined on small *Solidago* and sweet-clover plants under lamp chimneys. Three females collected on April 18 died on April 23. Two of the females apparently laid no eggs. Thirty-eight eggs were found in the abdomen of one and thirty-three in the other. The third female laid in all nine eggs, one of them being found alone in one leaf and the other eight in a group in another leaf. The latter were laid in a row along the slender petiole of the *Solidago* leaf. Both leaves in which the eggs were inserted were brown and withered and were found at the base of the plant. This same female was dissected and six eggs were found in the abdomen. Another female collected on April 19 died April 23 without laying any eggs. Forty-five eggs were found in her abdomen. Two other females were taken on April 24, from one of which, at this time of writing, only one egg has been obtained. It too was inserted in a partially dead leaf.

The eggs are inserted in the plant tissue. A longitudinal slit is made in the leaf and the egg deeply inserted, so that it makes a slight bulge in the leaf on the opposite side. The slit appears to be plugged with a whitish substance, which probably is part of the plant tissue.

NUMBER OF INSTARS.

The nymph passes through five nymphal stages, each stage differing from the others somewhat, both in structural detail and color.

LENGTH OF THE STAGES.

The length of the various stages was difficult to determine, due to the difficulty in rearing the insects. The work accomplished during the summer of 1921 was of little value. It was started with nymphs of the third, fourth and fifth instars. These were brought into the laboratory on large cuttings of host plants, which were placed in water and covered by lamp chimneys. The intention was to change the spittle insects to fresh plants as quickly as the original ones wilted. Apparently there was not enough plant juice to supply the amount of fluid for so many new masses of spittle necessitated by the changes. A few nymphs, however, were carried through to adults. In the spring of 1922, having obtained the very small first

instars, and using a different method of rearing, better results were obtained. Various host plants were planted in small flower pots, and the insects were confined on these under lamp chimneys. This was an improvement over the first method, although not entirely satisfactory. By having the living plant a more steady flow of sap could be obtained, so that the insect, once established was able to proceed without interruptions. The chief difficulties to cope with were in getting the very restless first instars settled, and the fact that the plants became stunted and sickly under glass chimneys. Wire cages would have been more satisfactory for the rearing of the later nymphal stages, but would have been too open for the first instar. From some fifty-odd groups of experiments, only seven first-instar nymphs were carried through to adults. Other reliable data for the various stages were obtained piecemeal by counting the length of time from molt to molt. The rearings were carried on on a back porch, so that the temperature was practically the same as in the field.

First-instar nymphs taken in the field remained the following number of days in this stage:

April 29 to May 5	7 days	May 12 to May 21	9 days
May 2 to May 9	7 days	May 12 to May 19	7 days
May 3 to May 10	7 days	May 12 to May 20	8 days
May 4 to May 14	10 days	May 12 to May 21	9 days
May 6 to May 17	11 days	May 12 to May 14	2 days
May 12 to May 17	5 days	May 11 to May 21	10 days

This gives a range of from two to thirteen days for the instar. However, these data are not sufficiently accurate, since the nymphs were not obtained directly from the egg, but were picked up promiscuously in the field. Some of them appeared to have just hatched. The average time is probably ten or eleven days.

Records for the second instar are as follows:

May 17 to May 25	8 days	May 21 to May 27	6 days
May 17 to May 22	5 days	May 25 to June 3	9 days
May 21 to May 27	6 days	May 22 to May 24	2 days
May 19 to May 25	6 days	May 22 to May 27	5 days
May 19 to May 26	7 days	May 22 to May 28	6 days
May 21 to May 29	8 days	May 24 to May 31	7 days
May 14 to May 21	7 days	June 26 to June 30	4 days

These are accurate counts taken from molt to molt. The range is from two to nine days and the average length seems to be six or seven days.

Third-instar nymphs lived from—

May 25 to May 31	6 days	June 3 to June 9	6 days
May 22 to May 29	7 days	May 24 to June 5	12 days
May 27 to June 6	10 days	May 28 to June 8	11 days
May 25 to June 1	7 days	May 31 to June 13	13 days
May 26 to June 3	8 days	May 27 to June 4	8 days
May 29 to June 6	8 days	June 30 to July 6	6 days
May 21 to May 30	9 days		

These are also counted from molt to molt. The range is from six to thirteen. The average is eight.

The fourth stage lasted from—

May 31 to June 8	8 days	June 5 to June 14	9 days
June 6 to July 1	25 days	June 13 to July 7	24 days
June 1 to June 11	10 days	May 31 to June 12	12 days
June 3 to June 12	9 days	June 5 to June 13	8 days
June 6 to June 16	10 days	June 6 to June 13	7 days
May 30 to June 9	10 days	June 8 to June 14	6 days
June 9 to June 18	9 days	June 1 to June 25	24 days

The range is from six to twenty-five and the average is between nine and ten.

The fifth stage lasted from—

June 8 to June 19	11 days	June 18 to June 29	11 days
June 1 to July 15	14 days	June 14 to June 24	10 days
June 11 to June 26	15 days	July 7 to July 20	13 days
June 12 to June 28	16 days	June 12 to June 30	18 days
June 16 to July 8	22 days	June 14 to June 25	11 days
June 9 to June 23	14 days	June 25 to July 9	14 days

The range is from ten to twenty-two and the average between eleven and fifteen.

The seven complete histories from first instar to adult are as follows:

Number.	First.	Second.	Third.	Fourth.	Fifth.	Totals.
1	11	8	6	8	11	44
2	9	6	10	25	14	89
3	7	6	7	10	15	45
4	7	7	8	9	16	47
5	9	8	8	10	22	57
6	2	7	6	10	14	39
7	13	9	6	9	11	48

From the foregoing data it is apparent that there is a wide variation in the length of any stage, which is probably due to the nature and condition of the food plant and the abundance of the sap.

Field observations also show a wide variation in the length of the stages. In 1922 the first-instar nymphs were taken on April 29 and

the last one on June 23, while they reached their maximum abundance between May 11 and May 16. Second-instar nymphs appeared May 4, reached their maximum number about May 18 to May 27, and disappeared around June 20. Third instars were first taken about May 11, were most abundant from May 29 to June 3, while fourth instars appeared about May 16 and reached the maximum from June 7 to June 10. The first fifth instars were taken on June 2. They were most abundant from June 13 to June 20 and began to thin out by June 27, the last two being taken on July 4. The average total of days for the nymphal stages is perhaps forty-five days.

HABITS OF NYMPHS.

Perhaps the first thing of interest to note about the nymphs is their restlessness in the laboratory and their agility in moving around. Since they are always found in spittle masses, it is only natural to think of them as being rather inactive, helpless larvæ, but such does not appear to be the case. The first-instar nymphs especially are most active. In fact one of the greatest difficulties to overcome in the rearing of these insects was the continual moving of the first instars. When collecting, if the larvæ were brought away undisturbed in their spittle masses they usually were found missing on arriving at the laboratory. A satisfactory method of taking them is to wrap the plants in an improvised envelope of newspaper and carry them away in this fashion. When the nymphs are transferred to new plants it takes them some time to become settled. They ramble aimlessly over the plant, seemingly looking for the most favorable feeding ground. In one instance a nymph was observed which wandered the entire length of the stem and back again, then out on the leaf, where it rambled all over the surface, and even hung poised in the air, walking on the extreme margin of the leaf. During this wandering period they repeatedly fall off the plant on the dirt, where, if they happen to light on their backs, they struggle to regain their feet, and usually perish in the attempt. They dry up very quickly if not living in their spittle masses. Many times they crawl from the plant to the ground and reach the surface of the glass globe, where ensues a struggle to climb up the slick glass. Several times during their wanderings the first instars have disappeared entirely, crawling through two thicknesses of cheesecloth.

This restlessness of the nymphs is apt to be incited in two ways, namely, by disturbing them in the spittle mass and because of lack of juice from the plant. While looking for molted skins it was

usually necessary to shove the insect around in the spittle mass in order to see the skin, and this often disturbed the nymph so much that it would immediately hunt a new place.

Lepyronia nymphs have a comical appearance while walking over the plant. Their legs are long and they walk with their bodies lifted high in the air. Sometimes they walk exceedingly fast, but at other times they merely creep along. Occasionally the nymph extends its abdomen in the air at right angles to its body, first expanding it and then contracting it in a telescopic manner; it does this even while it walks.

The gregariousness of spittle insects is plainly evident, although it probably is due more to chance than instinct. A probable explanation is that in their roaming over the plants they encounter other spittle masses, and it is much easier to stay in this than to make a new mass. In many cases three or four instars have been found together in the same spittle mass. For this reason, toward the last of the season the first instars are not so readily seen unless each spittle mass is examined, since they are found deeply imbedded in the spittle mass made by larger nymphs. On one stalk of *Ambrosia trifida* (horseweed) three inches of solid spittle were found extending all around the stem. In the mass there were thirty-one insects, of which sixteen were fourth instars, ten were third instars, and five were fifth instars. Fifteen molted skins were found in it also. On another plant were found three large masses of fourth and fifth instars, which were packed so closely together that the spittle scarcely covered them. Spittle masses were very large and abundant on elm sprouts; one stalk bore a mass of spittle which extended four inches along the stem; another branch bore eleven masses. On another host plant two large masses of spittle were found, one mass containing six nymphs and the other six or ten. On June 13, on a single plant of *Ambrosia trifida* a spittle mass twelve inches long was found, which contained sixty-eight or more nymphs. The spittle was white and foamy, but was barely enough to cover the nymphs, since the form of their bodies could be plainly seen through it.

In the literature it is often stated that the nymph lives and molts in the same mass of spittle until the adult form is reached. Comstock (1895), in his brief discussion of Cercopidæ, states that it had been asserted that they undergo all their changes in the spittle mass. Girault (1904) says of *Aphrophora parallela* (Say), that they seldom move unless disturbed, and Garman (1921), in his work with *Phil-*

œnus lineatus (Linn.), states that during nymphal life the bug may construct several balls, but that there usually is little migration after the first mass is formed. Kershaw (1914), on the other hand, is of the opinion that the nymphs of *Tomaspis saccharina* usually, but not always, leave the spittle mass after a molt.

In the study of *Lepyronia quadrangularis* an experiment was attempted to determine just to what extent these migrations were carried on in the field. Four goldenrod plants bearing spittle masses were marked with white rags about May 12. It was difficult to determine in what stage the nymphs were at this time, since it was not thought best to disturb them, but they appeared to be in the latter part of the first stage. On May 16 three plants had second instars on them and the fourth had a second- and a fourth-stage nymph in one mass. On May 27 these plants were observed again. One plant was entirely deserted, but the other three appeared to be all right, with the spittle masses in practically the same position. June 2 found them practically the same, but other weeds were beginning to crowd around them so that little data thenceforth could be obtained. On June 7, however, one or two new masses of spittle were found on each of the marked plants, including the deserted one, which now bore three masses. This seems to point to the conclusion that the nymphs do move in the field even when not disturbed. Frequently, while collecting, molted skins can be found in deserted spittle masses.

In captivity, at least, as was stated above, the nymphs move considerably. Following the records of a few reared from first instars to adults may illustrate this fact. One first instar collected on May 6 was placed on a plant and soon formed a spittle mass. On May 17 it molted to a second instar, remaining in the same mass of spittle until May 18. On this date it moved farther down on the plant and made a new mass. It remained in this mass of spittle until June 7, in the meantime having molted on May 23 and May 25. After this last migration it formed a new mass of spittle higher up on the plant, where it remained until emerging as an adult. Another nymph, collected on May 12 and reared to adult, moved only twice, both times being between molts and not just after. Still another moved three times during its five changes. A fourth specimen, collected in the second stage, moved six times before emerging as an adult, and only once moved directly after molting. From the foregoing there appears to be no fixed habit of moving after each molt.

They probably move from lack of food or because of disturbances, and in the field, if they find a favorable place, they may stay in one place throughout their period of growth.

The size of the spittle mass varies for each instar, being in proportion to the size of the nymphs. The first-instar nymphs, at least the recently hatched ones, are covered by a clear drop of fluid with very little foam, and for this reason are easily discovered in the field. In fact, they were originally discovered by means of these clear drops of fluid. When walking through the weeds the writer's attention was attracted by these shiny drops of fluid on the vegetation, and upon closer examination it was found that they came from the spittle nymphs, which were usually found on the under sides of the leaves, and for this reason are not easily seen. The spittle masses of the other instars are usually foamy and puffy in the field.

When the insect is ready to transform into an adult an interesting change in the spittle mass takes place. The superficial part of the foam dries and stiffens somewhat, so that it forms a roof to a closed chamber. Within this chamber the molt occurs, and the adult can be seen distinctly in this mass. It usually takes a day for the adult to harden sufficiently to emerge. If they are removed from the mass too soon they do not gain their full color, but have a yellowish-tan appearance. When the adult is ready to emerge the slightest disturbance causes it to give a strong leap, thus freeing itself from the spittle ball and leaving a round opening in the latter. Empty chambers are found quite frequently in the field.

In captivity all the instars made comparatively little spittle. In a good many cases they lived chiefly in the fluid without producing many bubbles. When the spittle was produced it usually was just sufficient to cover them. The fourth- and fifth-instar nymphs were able to make the most spittle, but even these did not reach the proportion of those in the field.

The process of froth-making in the Cercopidæ has been a topic of discussion for some time. The earliest conception of the spittle masses was that they were voided by tree frogs. Fabre (1900), in the discussion of froth-making by *Aphrophora spumarius*, which in his picturesque way he calls the "cicadelle," says that the peasants of France give another name to this substance. They call it "cuckoo spit," because the little balls occur at the time of year when this bird returns from its migrations. The early entomologists assigned the spittle to its correct cause, but they thought that the foam

was exuded from the anus of the little nymphs. This viewpoint was summarized by Harris (1862) as follows: "Here may be arranged the singular insects called froghoppers, Cercopidæ, which pass their whole lives on plants, on the stems of which their eggs are laid in the autumn. The following summer they are hatched and the young immediately perforate the bark with their beaks and begin to imbibe the sap. They take in such quantities of this that it oozes out of their bodies continually in the form of little bubbles, which soon completely cover up the insects."

In 1900 several papers on froth formation were published by European and American writers. Morse (1900) is generally given the credit for discovering that the insect emits a liquid only and later enfolds air bubbles in the liquid. His original account really appeared in 1875 in his "Elementary Zoölogy." Fabre (1900), Gruner (1900), and Sulc (1900) concluded the same thing, but they all differ as to the method by which the result is obtained.

According to Morse (1900) a clear fluid is emitted by the nymph, which flows over the entire body and fills up the crevices between the legs. Next the insect extends the abdomen out of the fluid, opens the posterior segments like claspers, grasps a bubble of air, and then turns the abdomen under the fluid, allowing the inclosed air to escape. According to him, the movements go on at the rate of seventy to eighty times a minute and thirty to forty bubbles were made in a half hour. He says that the claspers seem to be the tergal portions of the ninth segment.

Fabre (1900) describes a similar apparatus. According to him, the insect has a special device, which is composed of the two pleural lobes of the ninth segment, acting as claspers for grasping air, and a pocket, formed by these lobes, which serves as a container for air. From a caudal view of the abdomen, when the two pleural lobes are drawn apart, a y-shaped opening in the pocket is produced, or, in other words, the expanding and contracting of these lobes opens and closes the pocket. In producing the bubbles the tip of the abdomen is thrust out of the liquid, the pleural lobes spread apart, letting air into the pocket, then close together again, and at the same time the abdomen is pulled under the fluid. At this point the pocket, being flexible, contracts, and thus forces air out of the pocket, forming a bubble in the viscid fluid.

The explanation of bubble formation advanced by Gruner (1900) is similar to that of Fabre's in that he too describes a pocketlike cavity and two terminal clasping plates. He maintains, however,

that the air for the bubbles is supplied from the tracheæ. The following is his account of the process: "Soon after the larvæ have fastened themselves head downward on the plant and have imbibed some of the sap, the terminal portion of the abdomen rythmically contracts so that the fluid from the anus is exuded and flows into the cavity or pocket. The insect being head downward, the fluid flows into the pocket, where it becomes mixed with air coming from the last few pairs of spiracles. Bubbles are thus produced in the pocket by the contraction and expansion of the tergal plates."

Sulc (1910) describes a still different apparatus, namely the air canal. He says that the "pochette" of Fabre and the "tasche" of Gruner is not present, but that the special device is the air canal (pl. LXII, figs. 6 and 7). This air canal or channel is formed by the tergal pads or plates. Beginning with the fourth segment and extending to the ninth, the plates are prominent and are capable of touching on their median margins. The plates of the first and second segments are short and widely separated from each other. The tergal plates of the third abdominal segment are triangular, so that only their posterior medial margins can touch each other. Arising from the median portion of the third sternite between the two plates there appears a special triangular, caudad-projecting protuberance (pl. LXII, fig. 6), which serves to close the channel. Thus the tergal plates form a channel which extends directly from the ninth segment to the middle of the third. At this point it becomes Y-shaped, dividing into two smaller channels, which continue to the right and left until the hind margins of the thorax are reached. When the cercopid is submerged in the spittle the tergal pads are pressed firmly together by means of the contraction of strong muscles, and the tip of the abdomen just reaches the surface of the spittle. According to Sulc, the froghopper nymph can be compared to water-dwelling insects with open, tracheal systems, only deviating from all hitherto known examples by having this special device of the air channel. When fresh air is desired the tip of the abdomen is thrust out of the spittle, the air channel opens and the air enters. Immediately the air channel is compressed and at this moment a bubble is released in the spittle mass.

The writer's own observations were made before reading the above descriptions. It was very difficult to view this process at all, because of the difficulty of getting the nymphs to settle on the cut plants, and when they made the foam on living plants it was almost impossible to focus the microscope on them. Most of the observa-

tions were interrupted before much data could be obtained. The longest observation was that on a fourth instar, which started making spittle on a large leaf which could easily be placed under the microscope. It started making spittle at 9:40 a. m. At this time the abdomen was extended in the air, and from the slitlike opening in the anus could be seen to exude a clear fluid, which flowed down beneath the body in the ventral channel or air canal of Sulc. A second or so was spent in ejecting this fluid, and then the insect began dipping the abdomen in and out of this fluid, each time producing a bubble. It did this for ten times, and then the abdomen was lifted high in the air twice and the terminal plates were spread far apart. When a number of bubbles was produced the abdomen was pulled beneath them and then brought up through them so that they were separated and pushed on each side of it. When reaching after air the plates were spread far apart, but at the surface of the spittle they came together. The farther out the abdomen was extended and the slower the movements the larger the bubbles were. The abdomen was next pulled down deeply in the spittle and a few small bubbles were produced. Again the nymph rested for a minute or so, while more fluid flowed from the anus. At times the nymph kicked rapidly with its two front pair of legs, making the bubbles go to the side, and during the whole performance one front leg was constantly kicking so that gradually the bubbles were worked headward. Again it made bubbles, rested for three and one-half minutes, while the body was straightened out until the spittle was all around the side and partly on the side of the head. Another cessation of bubble-making lasted for six minutes. Later the nymph lay almost on one side with the bubbles entirely on the other side. Next more fluid was ejected until the body was entirely surrounded and the bubbles pushed entirely to the edge of the fluid mass. A rest of ten minutes followed. At 11:10 it had not ceased making spittle, and the insect was still visible, although the entire body was covered by a thin sheet of foam. At 11:45 there was considerable more spittle and the nymph was still working.

Another nymph was watched. It started making spittle at 8:20, and in fifteen minutes had enough spittle to make a thin covering for its body.

From a study of the nymphs of *Lepyronia* it appears that Sulc has described the process more accurately than any of the others. His description seems to differ only in extent from that of Fabre and Morse, both of which consider the two tergal plates of the ninth

segment of the abdomen as being the responsible machinery. Since these are the terminal plates, they naturally are the most prominent and under low magnification appear to do most of the work. From a translation of Sulc's work, it seems that he does not attribute the bubbles to the work of merely the last pair of plates, but to all nine pairs, which come together and form the air channel. He thus makes respiration and bubble-formation a simultaneous action. From observations of *Lepyronia* he is apparently right, since the writer has seen six pairs of plates in action very distinctly.

COMPOSITION OF THE FROTH.

The composition of the froth of spittle insects has been studied by different writers. They all have noted the viscid quality of the fluid, which they assert is necessary to maintain the frothy condition. Morse (1900) found that when nymphs were placed in water they immediately began clutching the air and making bubbles. The bubbles disappeared, however, as soon as made, for the clear water did not preserve them. Besides this viscidity, the spittle has a certain insolubility in water and alcohol. When collecting immediately after showers and heavy rains the spittle masses are found intact, even those which were in exposed places. In alcohol the spittle seems to coagulate in a stringy mass, which clings to the feet and body and is hard to pull away. Garman (1921) says that it is readily soluble in sodium hydroxide, has no reaction to iodine, although probably containing some sugar, and that the albuminous substance is not coagulated with heat. Gruner (1900) after several experiments comes to the conclusion that 94.565 per cent of the spittle fluid is water, 3.827 per cent organic substance, and 1.607 per cent inorganic salts. The spittle mass of *Lepyronia* can easily be told in the field from that of a *Clastoptera* by its composition. The spittle of the former contains more and larger bubbles and resembles the beaten white of egg, while the spittle of *Clastoptera* contains much smaller bubbles, which seem to be all on the outside of the mass, while the center of the mass appears to be a clear, gelatinous material. Kershaw (1914) states that the spittle of the nymph appears to be a mucin or mucinoid. He found that it granulates with subacetate of lead and stains deeply with methylene blue in glycerin and alcohol. Furthermore, the fluid appears to have every substance excreted from the anus, such as calcium oxalate, uric acid, leucine pellates and urates, potassium and sodium chlorides.

LONGEVITY OF ADULTS.

In 1921 the first adults were collected June 14 and the last ones on July 23. The latter date does not represent their last appearance, but merely the time when collecting trips ceased. In the spring of 1923 Mr. C. H. Curran collected specimens on April 1 and April 4, which was practically the first indication that they might overwinter as adults. By the first part of May adults were no more in evidence. Adults hatching from eggs in the spring began to appear on June 13, becoming quite numerous by June 19. The rest of the summer and fall adults could be taken in great numbers, sometimes averaging seventy-five in one hour's collecting. The last date in the fall was November 23. In the spring of 1923 adult females were first taken on April 19. From these facts it appears that the insects, at least the female, spends the greater part of the year in the adult form—from the middle of June until about the middle of April, or a period of ten months.

HABITS OF ADULTS.

The adult bug is a very sluggish insect. It sits for hours on the stems and leaves of plants, feeding continually. Many were found on thistle plants, where they could be easily watched. Some were under observation for two hours, during which time they never changed position. While feeding they emit a clear fluid or honey dew, which falls from beneath them in large drops. One individual was watched for an hour, during which time 200 drops of honeydew were emitted. While feeding they usually sit with their legs folded snugly beneath the wings. When walking they seem to spread the two front pairs of legs out to the side, propelling themselves along by them, but the hind pair are held straight beneath the wings and dragged along behind, evidently only of use in jumping. When disturbed froghoppers give a powerful leap, and for this reason are hard to collect. The best method of collecting them is by sweeping and then holding a large-sized test-tube in front of them in such a position that they will hop into the tube, since they always jump in a forward direction.

MATING.

Mating takes place in the late fall. On September 27 two pairs were found mating in a cage in the insectary. On September 28 one pair was caught in the field while mating and two pairs in an inside cage. A day later two more pairs mated, and on September 30 another pair and on October 2 still another, making nine pairs in all. After this the males probably die and the females go into winter quarters.

FOOD HABITS.

The nymphs and adults of this cercopid have a wide range of food plants. The nymphs have been found feeding on sixty-two species of plants, which are as follows:

Actinomeris alternifolia	Compositæ.
Agrimonia gyrposepala (agrimony)	Rosaceæ.
Ambrosia trifida (horseweed)	Compositæ.
Ambrosia artemisiifolia (ragweed)	Compositæ.
Andropogan furcatus	Gramineæ.
Apocynum cannabinum (dogbane)	Apocynaceæ.
Apocynum pubescens	Apocynaceæ.
Asclepias syriaca (common milkweed)	Asclepiadaceæ.
Asclepias tuberosa (butterfly weed)	Asclepiadaceæ.
Asclepias verticillata	Asclepiadaceæ.
Aster paniculatum	Compositæ.
Aster salicifolius	Compositæ.
Bromus secalinus (chess or cheat)	Gramineæ.
Chenopodium album (lamb's-quarters)	Chenopodiaceæ.
Cirsium altissimum (thistle)	Compositæ.
Cornus baileyi (dogwood)	Cornaceæ.
Erigeron canadensis (butterweed)	Compositæ.
Erigeron ramosus (daisy fleabane)	Compositæ.
Eupatorium altissimum	Compositæ.
Galium aparine var. vaillántii (cleavers)	Rubiaceæ.
Geum canadense (avens)	Rosaceæ.
Geum strictum (avens)	Rosaceæ.
Helianthus grosserratus (?) (sunflower)	Compositæ.
Helianthus petiolaris	Compositæ.
Heliopsis scabra (oxeye)	Compositæ.
Juglans nigra (black walnut)	Juglandaceæ.
Lactuca canadensis (wild lettuce)	Compositæ.
Lactuca pulchella (?)	Compositæ.
Lactuca scariola	Compositæ.
Lactuca spicata	Compositæ.
Lycopus americanus (?) (water horehound)	Labiatæ.
Melilotus alba (sweet-clover)	Leguminosæ.
Morus rubra (red mulberry)	Urticaceæ.
Osmorhiza claytoni (sweet cicely)	Umbelliferæ.
Panicum virgatum	Gramineæ.
Panicum wilcoxianum	Gramineæ.
Phleum pratense (timothy)	Gramineæ.
Plantago rugelii (plantain)	Plantaginaceæ.
Prunella vulgaris (heal-all or carpenter weed)	Labiatæ.
Rhus glabra (smooth sumac)	Anacardiaceæ.
Robinia pseudo-acacia (black locust)	Leguminosæ.
Rosa setigera (wild rose)	Rosaceæ.
Rubus canadensis	Rosaceæ.
Rubus occidentalis (black raspberry)	Rosaceæ.

Rudbeckia fulgida (coneflower)	Compositæ.
Ruellia ciliosa	Acanthaceæ.
Ruellia parviflora	Acanthaceæ.
Sanicula canadense	Umbelliferæ.
Sanicula marilandica (black snakeroot)	Umbelliferæ.
Solidago altissima (goldenrod)	Compositæ.
Solidago rigida	Compositæ.
Sphenopholis obtusata	Gramineæ.
Stachys palustris (hedge nettle)	Labiatæ.
Symphoricarpos orbiculatus (coralberry)	Caprifoliaceæ.
Taraxacum officinale (dandelion)	Compositæ.
Triadenum virginicum (marsh St. John's wort)	Hypericaceæ.
Tridens flavus (tall redtop grass)	Gramineæ.
Triticum vulgare (wheat)	Gramineæ.
Ulmus fulva (slippery elm)	Urticaceæ.
Urtica gracilis	Urticaceæ.
Verbena urticaefolia	Verbenaceæ.
Vernonia baldwini (ironweed)	Compositæ.

Among this list of plants there are nineteen families of plants represented. The families containing the most species are the Compositæ, Gramineæ and Rosaceæ, which have twenty, nine and five species, respectively. In early spring the first nymphs were found in one small plot of *Solidago* plants. Later they were found on other groups of plants, such as aster, grasses and giant horseweed (*Ambrosia trifida*). Toward the last part of the nymphal season the most popular single food plant, perhaps, was *Ambrosia artemsiifolia*, or ragweed. It was chiefly on *Ambrosia trifida* and *Cirsium altissimum*, however, that the large masses of spittle containing so many nymphs were found.

The spittle masses are usually found along the plant stems, although with broad-leafed varieties of plants, such as plantain and elm, they are also found on the back of the leaves.

Not only did the nymphs collectively show a remarkable diversity of choice of food plants, but each individual nymph seems to have no restriction to any particular plant. Nymphs feeding on thistle in the field could be brought into the laboratory and reared on ragweed. In the cages where several species of plants were growing together, such as ragweed and lamb's-quarters, nymphs have been observed to migrate from one to another several times during their development.

Fabre (1900) discusses this strange disregard, as he calls it, of genera and species of plants. He says that it would be hard to make a list of the plants in his neighborhood which have been lacking in spittle. With a brush he picked up nymphs feeding on one

species of plant and deposited them on a new plant of entirely different flavor, only to find that the new was accepted without hesitation. He found that the insect could easily be transferred from the bean, a plant of mild flavor, to the spicy euphorbia, and back again. It also could be transferred from such pepper plants as *Arum italicum,* of which it takes only a small portion of the leaf to burn the lips, to the perfumed marum and common dandelion. In order to find the explanation of this Fabre carried on the following experiments. He first discovered that when he punctured a euphorbia plant with a small instrument, the milky, poisonous sap oozed forth, but that when the beak of the insect was pushed in only a colorless, neutral fluid was obtained. In fact, the nymph soon perished in the milk of the euphorbia, because of its caustic properties. He therefore concludes that the siphon of the cicada, by a selection which should be envied, selects at the bottom of the puncture the substance it needs for food, which is the same in all plants, and therefore produces the same colorless fluid, no matter what the species of plant is on which the nymph is feeding.

Other observers have found this species feeding on additional host plants. Gillette and Baker (1895) took it on *Clematis ligusticifolia* and *Carex* (Gillette). Lintner (1895) found it very common in groves of sugar maple, "where numbers of them were often met with, drowned in vessels of sap." Osborn (1916) took it on *Impatiens biflora.*

NATURAL ENEMIES.

It is generally conceded that the froth or spittle is a protective measure. This is undoubtedly the case, for cercopid nymphs are remarkably free from parasites or predators. A *Syrphus knabi* was found sucking at a spittle mass for a short while, but soon flew away without causing any disturbance. At one time a nabid nymph was found sucking the nymph of *Clastoptera proteus.* The latter was found about two inches away from the nearest spittle mass, and probably had just left the mass when it was captured by the nabid nymph. Three adults of this same species of cercopid were found in the web of a small spider. They were all dead. Gruner (1900) experimented with red ants and the nymphs of *Aphrophora* and *Philænus.* If he placed the nymphs, without any spittle, near the ants, the latter immediately pounced on them and began dragging them away. However, when he placed grass tufts, bearing nymphs in spittle masses, near them, the ants immediately covered the tufts,

but as soon as the mass was reached would stop and turn back. Garman (1921) states that the spittle ball offers an ideal medium for molds and bacteria, which may sometimes be found in large numbers. None of these organisms were found in the spittle balls of *Lepyronia*. Urich (1913) in his studies of Trinidad froghoppers has found that they are preyed upon by two birds, a reptile, batrachian, spiders, predatory insects, and is the host of two parasitic insects and a parasitic worm, which all together play an important part in the control of these froghoppers. Williams (1923) reports the larvæ of *Drosophila paradoxa* living in the spittle mass of a *Clastoptera*. He states that they undoubtedly kill some of the spittle nymphs. Considering the family as a whole, however, it is evident that froghoppers have few natural enemies, and this probably is due to the protection of the viscid spittle material.

DESCRIPTION OF DIFFERENT STAGES.

THE EGG.

Length, 1.2 mm.; width, 0.3 mm. Elongate, slightly curved, tapering to a rather sharp point at one end and to a more blunt one at the other end. They are white in color, somewhat transparent, and the surface is smooth.

FIRST INSTAR.

Size. Average length, 1.53 mm.; width across eyes, 0.456 mm.; width across abdomen, 0.549 mm.

Color. Head and thorax yellowish white washed with brown, the mesothorax and metathorax darker gray-brown. The abdomen is a bright yellow, with a pair of oval, orange spots occupying the lateral and part of the dorsal and ventral surfaces of the fourth, fifth and sixth segments. The eyes are reddish brown and the legs yellowish white washed in brown, especially at their bases.

Structural characteristics. The anterior portion of the head is bulblike, distinctly rounded and with the clypeus greatly inflated. The division between the front and vertex is indicated by a short line cephalad of each antenna, which runs mesad. No ocelli are present. The antennæ have nine segments, the basal segment a short, stout one, the second and third elongate-stout, and the fourth fan-shaped, with the distal five segments ringlike. There is no evidence of wing pads from a dorsal view, and only a faint indication from the lateral view in the form of a slight caudal extension. The legs have proportionately greatly elongated coxæ and have only two segments in the tarsus, a short basal one and a longer distal one. Pleural lobes are not conspicuous.

SECOND INSTAR.

Size. Average length, 2.02 mm.; width across eyes, 0.525 mm.; width across abdomen, 0.699 mm.

Color. Body is pale yellowish-white. Head is washed in reddish-brown. Prothorax is pale yellowish-white only slightly washed in grayish-brown. Mesothorax and metathorax are darker gray-brown. Orange spots on abdomen are only faintly visible.

Structural characteristics. Practically the same as in the preceding instar The wing pads show no marked development. The mesothorax and metathorax together are equal in length to the prothorax. Clypeus is slightly more inflated than in the first instar.

THIRD INSTAR.

Size. Average length, 3.75 mm.; width across eyes, 1.05 mm.; width across abdomen, 1.33 mm.

Color. Body is pale whitish-yellow, with considerable more yellow than in the second instar. Head and thorax are unchanged in color.

Structural characteristics. The wing pads are plainly visible as caudal extensions of the lateral angle of the thoracic tergites, the first pair more prominent than the second. The mesothorax is equal in length to the prothorax and about twice the length of the metathorax. Two ocelli are present and are black in color. Antennæ with nine segments, but the terminal five segments are much elongated.

FOURTH INSTAR.

Size. Average length, 4.48 mm.; width across eyes, 2.57 mm.; width across abdomen, 2.17 mm.

Color. Body pale greenish yellow. Head washed with reddish brown. Thorax varies from pale yellow to dark brown on mesothorax and metathorax.

Structural characteristics. Antennæ are practically the same in shape, but more elongate. The first pair of wing pads are produced caudad until their apices almost reach the apex of the second pair. The exposed portion of the second pair is but little longer than that of the first pair.

FIFTH INSTAR.

Size. Average length, 6.94 mm.; width across eyes, 2.57 mm.; width across abdomen, 2.17 mm.

Color. Body whitish green with very little yellow. Head and thorax are generally of the same color as the body.

Structural characteristics. Lateral angles of the first pair of wing pads are more produced and as long as the second pair. Second pair are also greatly enlarged both in width and length, reaching the third segment of the abdomen. Prothorax has the adult form with its emarginate posterior margin. Median portion of mesothorax, is produced caudad until it almost touches the posterior margin of the metathorax. Metathorax also slightly produced caudad. On the metathoracic leg indication of the third tarsal segment is shown; the two rows of spines on the distal end of the tibia are also present, and the rows of spines on the distal end of each segment of the tarsus are faintly visible. The two front pairs of legs still have two segments in the tarsi and have two rows of spines on the distal end of the tibiæ which are not present in the adult.

NOTES ON THE DIFFERENT STAGES.

Structural differences between the first and second instars were hard to discover. The chief difference is in the size, although a few minor characters are sometimes evident. In the second instar the apex of the labium just comes to the first coxa, but in the first instar it extends to the second coxa, or at least between the coxæ

of the first pair of legs. In the second instar the length of the mesothorax and metathorax together is approximately equal to that of the prothorax, while in the first stage the prothorax is longer than the other two together and the mesothorax is slightly longer than the metathorax.

From the second to fifth instars color variation in the head and thorax can be found. Some specimens in each instar were both collected and reared in which the head and thorax were of the same color as the body. Others had head and thorax both washed in dark reddish brown, while still others had a pale prothorax with a dark mesothorax and metathorax, so that the thorax appeared to be distinctly banded. In the third and fourth instars the bands were of such dark-brown pigment that they appeared as black bands to the naked eye and made the nymphs very conspicuous. Apparently this color variation has no relation to sex, since both sexes have been found to have these different combinations.

On the fourth, fifth and sixth abdominal segments of the first instar appear two large, oval, orange spots. These spots make the first-instar nymphs more conspicuous and more vividly colored than any of the other instars. They probably indicate the location of the spittle glands which secrete part at least of the viscid fluid of the foam. Garman (1921) says that they appear as yellow spots on the side of the abdomen of *Philænus*, and Osborne (1916) found them as black spots in another species. Both writers state that the glands are found on the seventh and eighth segments, but in *Lepyronia* they are found on the above-mentioned segments. On the other hand, Kershaw (1914) says that the fluid is produced by the anterior or smooth portion of the malpighian tubes. The whole question is an interesting matter for further investigation.

ECONOMIC IMPORTANCE.

In general froghoppers are not considered economically important, since they are found feeding chiefly on weeds and wild plants. There are a few, however, which have been reported as doing considerable damage to certain cultivated host plants. Osborne (1916) thinks that the damage caused by froghoppers has been overlooked. According to him, *Philænus spumarius* L. considerably affects clover, for he noticed that the plants which are attacked wither and do not bear heads. He also has observed *Philænus lineatus* L. being so abundant on grass and hay crops as to occasion distinct losses, timothy and redtop being most frequently injured.

Ashley (1919) reports an *Aphrophora* in England which causes serious damage to roses during June and July by weakening the young shoots and buds by extracting the sap. Harris (1862) reports *Clastoptera proteus* as doing great injury to the cranberry crop in some parts of Massachusetts. The most destructive froghopper is the sugar-cane froghopper, *Tomaspis varia* Fabr., which is estimated by Urich (1913) as destroying ten per cent of the sugar crop of Trinidad. The damage which is done is called "blight" and consists of a withering of the leaves of the canes and a stunting of the stem. This is accomplished chiefly by the nymphs feeding on the roots, although the feeding of the adults on the leaves of very young plants may also cause it. Williams (1923) reports *Clastoptera theobromæ* Wills as destroying the flowers of the cacao in Panama.

No records of serious damage caused by *Lepyronia quadrangularis* have been found. Fitch (1856) records it on grape. The writer has found it on several economic plants, such as timothy, black raspberry, wheat and sweet-clover. Most of these, excepting wheat, were isolated plants or small groups of them, and therefore were not of much importance. In the case of the wheat, however, the matter was more serious. A good many stalks of wheat were found bearing spittle masses. These occurred chiefly at one side of the field next to the weeds, bordering a woods, and evidently they had migrated from the weeds to the wheat. In all cases where the nymphs were feeding on the wheat the heads were half the size of the good heads. Nine good heads were averaged, and the number of kernels was thirty-four to a head. Eleven poor heads were averaged, and the number was only ten, which makes an approximate loss of 33 per cent. From these observations, as well as those on the life history, the following conclusions can be drawn: That the insects by sucking the plant juices really cause considerable damage to the host plant; and they may become a menace to certain cultivated crops by their ability to migrate from one plant to another, and because, unless disturbed, they are so free from parasites and predators, they may greatly increase in number.

EXTERNAL ANATOMY.

Apparently little work has been done on morphology within the family Cercopidæ. In no case throughout the literature available for study has a thorough investigation of the structure of the entire body been made. One paper on the alimentary canal of a cercopid by Kershaw (1914), one on the respiratory system of a nymph of the Aphrophorinæ by Sulc (1910), and one by Metcalf (1916) on the wing venation of Cercopidæ, are the most extensive works to be found. Other brief references to the morphology of the Cercopidæ were found in a number of articles dealing with the homologies of certain special parts of the body among the families of Homoptera, namely, Taylor (1918) on the thorax, Kershaw and Muir (1922) on the genitalia of both sexes, Crampton (1922) on the male genitalia, and Hansen (1890) on the appendages and spiracles. One other article on the structure of *Aphrophora spumaria* by J. O. Harper (Science Gossip, 1874) concludes the list, but is of little value morphologically.

THE HEAD.

The terminology used in the discussion of the head is based mainly on that of Comstock and Kochi (1902), Martlatt (1896), and Funkhouser (1917).

The deposition of chitin is fairly heavy and uniform throughout the exoskeleton of the head. In fact, both dorsal and ventral surfaces are hard and brittle making dissection very difficult without first boiling in KOH.

A dense prostrate pubescence, consisting of thin, grayish hairs, covers the entire surface of the head. This gives the appearance of a grayish bloom, which partly conceals the coloration of the insect.

The *head* of *Lepyronia quadrangularis* (Say) resembles the other Homoptera in most of the essential parts, although it resembles some more closely than others. Perhaps it is more nearly like the Cicadidæ and Cicadellidæ when such points as the position of the head in relation to the body and the shape and comparative size of the sclerites are considered. The protruding, enlarged sclerite with its striated borders, commonly called the front, of *Lepyronia* instantly reminds one of the larger, homologous sclerite in the cicada. Likewise the heads of both these insects lie in nearly the same plane as the body, which condition is seldom found in other Homoptera outside of the Cicadellidæ. In *Lepyronia quadrangularis,* however, a flattening of the head dorsoventrally has taken place, with the result

that the vertex and the front lie entirely on the dorsal surface and the remaining sclerites on the ventral surface. Thus the anterior margins of the front and vertex (pl. LV, fig. 1) have been pressed against the anterior margin of the clypeus, which together form the cephalic and lateral margins of the head. The head, as is shown in the figure, projects straight forward on a line with the body and the beak projects backward and lies between the coxæ when at rest.

In the literature the most commonly accepted homology of the sclerites of the head are as follows: On the ventral aspect the large protruding sclerite (pl. LVI, fig. 2) is called the front; the smaller sclerite attached to its posterior margin, the clypeus; and the smaller triangular sclerite fastened to the clypeus, the labrum. The entire dorsal portion of the head (pl. LVI, fig. 1) is usually designated as the vertex, although it consists of two sclerites. The larger of these occupies most of the entire surface with the exception of the broad invagination in the cephalomedial region, into which a small subrectangular sclerite, the tylus, is inserted. There seems to have been no attempt to homologize or account for the existence of the tylus, although it appears as a definite sclerite in the adult and is partially indicated in the later nymphal stages.

Partly because of the lack of explanation with regard to the tylus and partly because of the suggestion of other workers in other groups, an investigation with regard to a different homology of parts was attempted. Funkhouser (1917) states that the clypeus in the Membracidæ is determined by the location of the anterior arms of the tentorium, which fully accords with the view of Comstock and Kochi (1902), that the anterior arms of the tentorium arise as invaginations of the body wall between the clypeus and front. He also refers to Bentley's work (1900) on the *Cicada,* which was unpublished, wherein the latter shows that the large, protruding sclerite known as the frons is really the clypeus. Several other articles in support of this theory have been found. Marlatt (1896) calls the sclerite in question (pl. LVI, fig. 2) the clypeus; likewise Smith (1892). Bugnion and Popoff (1911) state: "One of the characteristics of the clypeus is that it serves for insertion, with its deep face, of the anterior bundles of the dilator of the pharynx. A clypeus cleared in balsam shows in all Hemiptera the linear insertion of the striated membrane (of the pharynx) and the two sides of transverse lines which correspond to the insertion of muscles. Among some species (*Cicada*) the transverse lines are indeed seen from the exterior and give a particular appearance to

the sclerite. Without a doubt the clypeus of which they speak is the frons of other writers.

According to these writers, then, a different nomenclature from the commonly accepted one for the sclerites of the head of the *Cicada* has been used. The same thing holds true for *Lepyronia quadrangularis*. The sclerites on the ventral surface of head would be labeled clypeus, labrum and epipharynx (pl. LVI, fig. 2). In figure 1, the vertex remains the same, but the tylus would be termed the front.

A study of the tentorium and the position of the ocelli bear out this homology for both the *Cicada* and *Lepyronia*. As was mentioned above, Comstock and Kochi (1902) showed that the ends of the suture between the front and clypeus extend to the invagination which forms the anterior arms of the tentorium. From this it follows necessarily that the position of the tentorium would undoubtedly prove the identity of the front and clypeus in these insects. The tentorium (pl. LVI, fig. 3) is of practically the same shape in the *Cicada* and in *Lepyronia*. It consists of a slender transverse bar, which is the basal part or body of the tentorium, from which two long, slender, chitinous arms extend cephalad, and two short, posterior arms extend laterad. In the *Cicada* the basal portion is fairly narrow, not extending over one-third of the width of the occipital foramen; it occupies a central position in the head cavity. The anterior arms are by far the longest part of the tentorium and can easily be seen to run almost directly cephalad and slightly laterad to the point which marks the cephalolateral angle of the large protruding sclerite or clypeus. The tentorium in *Lepyronia quadrangularis* varies somewhat from that of the *Cicada*, but is essentially the same. In the cercopid the basal part of the tentorium is more extensive, in that it occupies about two-thirds of the width of the occipital foramen. The anterior arms extend in much the same direction as the *Cicada*, but their extreme anterior portions have become somewhat modified, due, no doubt, to the peculiar compression of the head. At this point it would probably be clearer to follow the figure (pl. LVI, fig. 3). In this figure the head is in the exact position as in figure 1, with the exception that the vertex has been removed in order to show the tentorium. The vertex appears to be very loosely attached to the tylus, for it can readily be lifted away. After the vertex has been removed the connection of the tylus and clypeus can easily be seen. The anterolateral corners of the clypeus are reflexed and the cephalic

margin of the reflexed corner has become strongly fused to the lateral margins of the tylus. It is not strange that with the peculiar arrangement of these sclerites, as well as the compression of the head on the anterior portion, that the tentorium has assumed a peculiar position also. In the first place, the anterior portion of the forearm of the tentorium has become forked. The prongs are blunt at the end and are of unequal length. The smaller one is attached to the skeleton of the head at a point about midway on the clypeus (fig. 3) and just back of the antennal pit. If the tentorium stopped here it would indeed be hard to identify the clypeus, since it is equally as far from either of the anterior margins of the two sclerites in question. Even in that case it would seem more plausible that it should have migrated backward due to the flattening of the head, already described, than that it should have migrated so far forward for no accountable reason. Fortunately, however, the other branch of the fork extends farther cephalad. It curves slightly mesad, following the free margin of the reflexed clypeus, although not touching it. In fact, it extends as far forward as the corners of the clypeus at the point where the latter is attached to the latero-posterior angle of the tylus. The tip of the branch appears to be attached by a membrane to the ental surface of the vertex. The significance of the position of the tentorium at this place in the attempt to locate the front and clypeus seems to be this: If the reflexed corners of the clypeus were bent back in their normal position and the front and vertex were laid out on the plane of the rest of the head sclerites, then the anterior arm of the tentorium would extend to the laterocephalic margin of the sclerite labeled clypeus in figure 3. The sclerites of the head from this view could easily be designated in succession as the vertex, front, clypeus, labrum and epipharynx without any intervening unexplained tylus.

Another argument for such nomenclature is the position of the median ocellus and its relation to the frons. Referring again to Comstock and Kochi (1902), we find a statement to the effect that the frons, in the more generalized insects at least, bears the median ocellus. Funkhouser (1917) is of the opinion that in the Membracidæ the frons has disappeared and with it the median ocellus which it contained. While Crawford (1914), in his work with Psyllidæ, states that in all cases where the frons is present it bears the anterior ocellus at its base or at the end nearest the vertex. In the Cicadidæ the median ocellus is distinctly located on the dorsal surface of the head in the sclerite just above that which is

generally called the frons. In *Lepyronia quadrangularis* there is of course no median ocellus present, but if it were present it seems highly improbable that it would be located on the ventral aspect of the head, so far removed from the other two ocelli. Its position would be more likely the normal one at about the place where the tylus is located.

The *compound eyes* (pl. LVI, fig. 1) are large but not very distinct on the dorsal aspect, due to the fact that their dorsal surfaces are level with the vertex, and the color of both is somewhat the same. They are oblong in shape, broader at the anterior end and narrower towards the posterior. They are located in the extreme caudolateral angles of the head.

There are two *ocelli* (pl. LVI, fig. 1) present, located about midway between the front and the pronotum and about as far from each other as from the compound eyes.

The *antennæ* (pl. LV, fig. 2) are located on the ventral surface of the head in a hollow pit halfway between the eyes and the clypeus and slightly cephalad of the eyes. In general appearance they are small and inconspicuous, appearing to consist of a very short basal stump and a long, thin, hairlike part which extends some distance beyond the sides of the head. From specimens stained with eosin and mounted on slides, more details of structure could be observed. The basal segments, called collectively the *shaft* or *peduncle,* are three in number. The first of these is subcylindrical, about as wide as long, and is apparently the widest of the three. The second segment is likewise subcylindrical, but approximately twice as long as wide, with its basal end slightly narrowed and its broader distal end cup-shaped. The last of the segments of the peduncle is the shortest, oviform in shape, and fits into the concave end of the second segment by means of a little stalk. The *flagellum* or *whip* consists of many segments, the exact number of which it was difficult to determine. After the first twenty-nine segments, extending two-thirds of the entire length, the segmentation becomes indistinct. In general these segments are cylindrical, but vary somewhat in shape, being longer than wide toward the tip of the filament and about equal in length and width at the base. The sense organs of the antennæ are located at the base of the filament and at the tip of the third segment of the peduncle. They consist of a small group of sensory pits, averaging about eight in number, and generally located close to the apex and somewhat to one side of the segment. Appearing to rise from the tip of this segment are three short, conspicuous thick spines, which are also sensory in function.

The *vertex* (pl. LVI, fig. 1), as has already been mentioned, makes up the largest area of the dorsal part of the head, transversely occupying all that part of the head between the compound eyes and longitudinally all the part between the occiput and tylus. In length and width it is about equal. In the anterior portion of the vertex is the subquadrate invagination into which the front is inserted. The suture between the front and vertex is very distinct and firm, but the parts of the vertex bounding the front laterally do not appear to be fastened to the latter, but only to fit down over the line of union of the front and the reflexed corners of the clypeus. The posterior margin of the vertex is broadly emarginate, into which the rounded margin of the prothorax fits snugly, while the lateral margins round to a blunt apex.

The *occiput* (pl. LVI, fig. 1) is not visible until after the head has been removed from the body, since it occupies the central portion of the caudal surface of the head, or that part which lies against the cephalic surface of the pronotum. It is a single sclerite, forming the upper boundary of the occipital foramen and the posterior boundary of the vertex. Laterad the lower ends of the occiput fuse with the postgenæ, so that the suture appears to stop at a point in a line with the inner margin of the eye.

The *postgenæ* (pl. LVI, fig. 1) occupy the remainder of the caudal surface of the head. They are triangular in shape, with the sharply tapering apex extending between the vertex and occiput. The upper boundary of each postgena is formed partly by the lower margin of the eye and partly by that of the vertex. Its outer margin is the outer limit of the head and its lower end is fused with the occiput.

The *frons*, or front (plate LVI, fig. 1), commonly spoken of as the tylus, as will be noted from the foregoing, is located on the dorsal surface of the head. It is subquadrangular in shape, about one-third the width of the vertex and about one-half its length.

The *clypeus* (pl. LVI, fig. 2) is located on the ventral surface of the head. Its position has been determined by the fact that the forearms of the tentorium extend to its laterocephalic angles.

The clypeus is enormously enlarged and protruding, subquadrangular in shape, widest in the middle and narrower toward each end. In size it extends practically two-thirds the length of the head and over one-half its width. On each lateral margin is a row of parallel grooves separated from each other by a plain, wide, chitinous band. These are lighter than the surrounding parts and therefore stand out clearly. The peculiar reflexed condition of the

anterior corners and their connection to the front have already been described under the discussion of the tentorium.

The *labrum* (pl. LVI, fig. 2) is a flask-shaped sclerite with its broad end attached to the clypeus and its apex truncated. In length it is half the size of the clypeus and in width equal to the width of the clypeus in the neighborhood of the clypeal suture, but narrows down to half the width at its distal end. The suture between the clypeus and the labrum is indistinct along the median line, but is plainly indicated at the sides. The labrum is heavily chitinized and appears to be quite rigid.

Attached to the caudal end of the labrum and lying on top of the base of the stylets is a small triangular sclerite. This is the *epipharynx* (pl. LVI, fig. 2). It is very thin and lightly chitinized, for which reason it is not readily seen.

The *genæ* (pl. LVI, fig. 2) occupy most of the lateral parts on the ventral aspect of the head. They are irregular in shape with their lateral margins following the contour of the compound eyes and their median margin touching the clypeus and the maxillary sclerite. Caudad they form the outer margin or boundary of the head, which also is the suture between the genæ and postgenæ.

The *occipital foramen* (pl. LVI, fig. 1) is the opening visible from the caudal aspect of the head. It is bounded dorsad by the occiput and laterally by the postgenæ and mandibular sclerites.

The *rostrum* (pl. LVI, figs. 1 and 2), or beak, is composed of the labium and two pair of stylets, which are modified maxillæ and mandibles. The *labium* is composed of three segments. The basal segment is the shortest of the three and cylindrical in shape. The second segment is the longest, being about three times the length of the first and twice the length of the distal segment. The last segment is rounded at the tip, its margins seemingly more completely folding around the stylets. The beak is straight and extends backward between the middle coxæ for half their length. The labium is connected by a membrane to both the head and sternum of the prothorax, its point of attachment being just above the tip of the labium. The attachment to the head seems to be the weaker of the two, for when the prothorax is detached from the head the labium usually comes off with it. There is a groove along the ventral surface of the labium, in which repose the maxillæ and mandibles.

The *mandibles* and *maxillæ*, as in other Homoptera, are setiform or bristlelike. The mandible is connected to the head by a slender,

chitinous rod at a point where the caudal corners of postgenæ are joined to the mandibular sclerite. The maxilla is fastened to the anterior corner of the maxillary sclerite, which places it cephalad of the mandible. Funkhouser (1917) states that in the Membracidæ they are attached to the vertex, which differs from the condition found in most other insects, where they are attached to the postgenæ. In *Lepyronia quadrangularis* neither of these conditions occurs, but the close approximation of the mandibular sclerite to the postgena may be significant.

In order to study the structure of the tips of the mandible and maxilla it was necessary to study them under high magnification. Both stylets are cylindrical in shape, tapering toward a blunt point and with their hidden bases broadening into flat plates. The outer margin of the distal third of the mandible is finely notched, while the outer apical part only of the maxilla is modified into five distinct, rounded teeth (pl. LVI, fig. 4). The maxillæ appear to be equal to the labium in length, but the mandibles are slightly longer, so that their tips protrude a short distance beyond the tip of the labium.

The four stylets are closely associated, converging at the place where the labium is attached to the head. Here the mandibles become joined together by their inner margins, forming a shallow sheath in which the maxillæ lie. The maxillæ are also united, probably forming a tube, as in the *Cicada* (Snodgrass, 1921), through which the sap is sucked up into the pharynx. The maxillæ of *Lepyronia*, however, do not appear to be so firmly joined as in the *Cicada*, for their tips often spread apart, until from a superficial view, they appear to be on the outside of the mandibles.

The *maxillary sclerites* (pl. LVI, fig. 2) are the large semicircular sclerites on the ventral aspect of the head, bounded laterad by the genæ, caudad by the mandibular sclerites, and mesad by the clypeus and labrum. The cephalic tip of each maxillary sclerite is connected to the maxilla by a slender, chitinized branch of the latter. These sclerites are homologous to the loræ of the Cicadellidæ. Snodgrass (1921) considers them as definite sclerites, but attaches no name to them.

The *mandibular sclerite* (pl. LVI, figs. 1, 2) extends from the caudal angle of the genæ and postgenæ to the base of the labium. Each sclerite is elongate, narrow at the base, but widening in the middle to a flangelike projection and tapering to a tonguelike apex which partially folds around the base of the stylets. The interior

surface of this flangelike part forms a pocket or fold, called by Martlatt (1895) a pseudo-sheath, which receives and partially protects the mandible. It is connected to the mandible, as in the maxilla, by a chitinous arm of the stylet. It may be possible that the mandibular sclerite is comparable to the sclerite found in lower orders of insects, which is termed the *trochantin of the mandible* by Comstock and Kochi (1902) or the *basimandibulæ* by Crampton (1921).

THE THORAX.

The prothorax, as is shown in (pl. LVI, fig. 6) is weakly attached to the mesothorax, but is closely associated with the head, since it invariably comes off with the head when the latter is removed from the body. The mesothorax and metathorax, however, are firmly joined and the sclerites somewhat overlap on the dorsal surface, making identification of the sclerites rather difficult.

There is no evidence of *cervical intersegmentalia* in *Lepyronia*, or of any structures which might suggest them. The cephalic surface of the prothorax appears to fit directly against the caudal surface of the head without any intervening structures which might be termed these sclerites.

THE PROTHORAX.

The *notum* (pl. LVII, fig. 1) of the prothorax is a large, flat sclerite occupying the entire dorsal surface of this segment. It is twice as long as wide and has its short, lateral margins nearly parallel. The anterior margin is broadly rounded. The posterior margin is deeply emarginate on the produced middle third. The edges of the notum are greatly deflexed so that they unite with the pleuron on the ventral surface.

From a cephalic aspect of the pronotum (pl. LVII, fig. 5) can be seen a narrow sclerite, which probably corresponds to the sclerite in the *Cicada* termed by Taylor (1918) the *pretergite*. Mesad this sclerite is very narrow, but laterally it widens out to four or five times its median width. It lies at right angles to the notum and is connected to the pleuron by a tapering projection. The pretergite is not as heavily chitinized as the notum and pleuron.

The *pleuron* (pl. LVII, fig. 3) of the prothorax is closely joined to the deflexed part of the notum without a distinct line of connection. It is divided longitudinally by a very indistinct *pleural suture* into two sclerites, the *epimeron* and *episternum*. The *episternum*, the anterior of the two, is roughly rectangular in shape and about twice as long as wide. The *epimeron* is slightly larger than the

episternum, more irregular in shape and extends dorsad into a tapering point. The episternum is connected to the sternum by a narrow *precoxale bridge* (pl. LVII, fig. 4), called the *precoxale* by Taylor (1918). It is fused to the ventroentad surface of the episternum and it is not distinctly separated from the sternum. The epimeron is connected in much the same manner by a *postcoxale bridge* (pl. LVII, fig. 4) which, however, runs to the laterodorsal angle of the epimeron instead of the ventral.

The *sternum* (pl. LVII, figs. 4 and 5) of the prothorax is small and about equal in length and width. It consists of a single sclerite, which is folded and curved in such a manner that it is difficult to describe its exact shape.

The anterior margin of the sternum is bent back against the caudal surface of the sclerite (pl. LVII, fig. 4), so that in an uncleared specimen it appears as a chitinous ridge or distinct sclerite. In the drawing of the cephalic aspect this has been straightened out into a natural position. The lateral margins of the sternum (pl. LVII, fig. 5) curve cephalad, thus forming a semicylindrical cavity into which the membrane connecting the labium with the sternum is fastened. During the process of sucking the sap the labium is probably drawn up into this trough in order to not interfere with the action of the stylets. The anterolateral angles of the sternum bear the *furca* (Taylor, 1918), which are the processes for the attachment of muscles.

The *trochantin* (pl. LVII, fig. 5) is a small but very distinct knob-like sclerite just below the ventral end of the episternum.

THE MESOTHORAX.

The *mesothorax* (pl. LVII, figs. 7 and 8) is closely connected with the metathorax, the latter being partially covered both on its dorsal and ventral surfaces by overlapping parts of the mesothorax. The mesothorax, likewise, is covered by the pronotum with the exception of the scutellum, the anterior margin of which follows the deeply incised posterior margin of the pronotum. The membranous sternellum of the mesothorax is fused with the presternum of the metathorax so that it is difficult to differentiate the two.

The *mesonotum* (pl. LVII, fig. 7) is divided into four distinct areas or sclerites. The first of these is the prescutum, which occupies the anteromesal portion and is bounded laterad by two longitudinal sutures which curve mesad for a short distance, thus indicating the caudal boundary of the sclerite. The prescutum is heavily chitinized in spite of the fact that it is entirely covered

by the pronotum. On its anterior margin it bears the *anterior phragma* (pl. LVII, fig. 7), a semimembranous, bilobed, narrow structure which is connected to the pronotum by a membrane.

The *scutum* (pl. LVII, fig. 7) of the mesothorax is an irregular sclerite, occupying the entire lateral regions of the notum. It appears to consist of two sclerites, since the anterior point of the scutellum almost reaches the caudal boundary of the prescutum. At its laterocaudal angles the scutum is deeply incised to allow for the wing processes.

The *scutellum* (pl. LVII, fig. 7) is composed of a large shield-shaped piece, which is visible externally and two narrow lateral portions which connect with the anal margins of the wing and are not visible externally. The large median part is separated from each lateral part by a narrow groove into which the deflexed claval portion of the wing fits.

There are several small sclerites to be found connecting the base of the wing with that of the notum. On the anterolateral corner of the scutum is a small piece, called by Taylor (1918) the *suralare*. It is marked by a cleft which extends forward. As in the *Cicada*, another cleft extending backward marks off a similar piece. Just in front of the incision made by these clefts is a small triangular, free plate, the *notopterale*. Caudad of this plate, imbedded in the membrane, is a larger, subrectangular plate called the *adanal pterale*. There is no indication of the presence of the *tegula*, which agrees with the conclusion of Taylor that the tegula is not present in the families of Homoptera outside of the Fulgoridæ and Cicadidæ.

Cephalad of the wing the notum is connected to the pleuron by a narrow *prealare bridge* (pl. LVII, fig. 7). The postscutellum is connected to the epimeron by a similar *postalare bridge* (pl. LVII, fig. 6).

The *postscutellum* is a narrow sclerite, entirely hidden by the scutellum and is membranous in structure.

The *pleuron* (pl. LVII, fig. 6) is somewhat more complicated than that of the prothorax. The pleuron, in fact, forms a major part of the ventral body wall, so that the shape of the episternum and epimeron can best be seen from a ventral view (pl. LVII, fig. 10.) The *pleural suture* (pl. LVII, fig. 6), is quite distinct, consisting of an almost straight line extending from the base of the prealare bridge to the base of the coxæ.

The *episternum* (pl. LVII, fig. 10) is a single sclerite, which is not divided into an anepisternum and katepisternum unless a diagonal elevated ridge is an indication of this division. The episternum

is irregular in shape, about as wide as long, and approximately equal to the length of the sternum. It is separated from the sternum by a distinct transverse suture. There is no precoxale bridge.

The *epimeron* (pl. LVII, fig. 10) is an elongate sclerite extending the entire length of the mesothorax. It is widest just behind the middle when viewed ventrally, and bears the *postalare bridge*, connecting it with the postscutellum just cephalad of its broadest point. The epimeron is partly divided longitudinally by a suture which runs parallel to the pleural suture, but which extends for only half its length. Like the episternum, it is fused to the sternum, being separated by the pleural suture.

The *sternum* (pl. LVII, fig. 10) of the mesothorax is composed of three sclerites—the presternum, the sternum proper, and the sternellum. The anterior one is the *presternum* (pl. LVII, fig. 10), which is a narrow collarlike sclerite, bounded laterad by the episterna and caudad by the sternum itself. It is slightly less chitinized than the sternum, especially towards its lateral margins. Along its anteromedian margin is a broad indentation into which the troughlike sternum of the prothorax is inserted.

The *sternum* (pl. LVII, fig. 10) is the major sclerite of the ventral part of the mesothorax. It is a bilobed sclerite, each lobe being somewhat inflated. They are separated from each other by a heavy, dark median line which resembles a suture. Just before this line reaches the caudal margin of the sternum it extends laterad as a short cleft which marks off a little flap on each lobe. The sternum is heavily chitinized and very dark colored. It is closely associated with the pleural sclerites, as was mentioned above, but is separated from both by very distinct and heavy sutures.

The *sternellum* (pl. LVII, fig. 10) is a partly membranous, partly chitinous sclerite, lying directly caudad of the sternum. It is a rather ill-defined region, somewhat semicircular, with its caudal, convex margin joined to the concave cephalic margin of the presternum of the metathorax. The chitin is deposited along the middle line of this sclerite as a broad, longitudinal band which sends out two lateral arms at its cephalic end which are entirely hidden by the overlapping sternum, and two lateral arms at its caudal end. The part of the sternellum which is chitinized is not very heavy, due to the fact that the large coxæ entirely cover it.

The *trochantin* (pl. LVII, fig. 10) is a very small but distinct sclerite, located between the laterocaudal angle of the sternum and the laterocephalic angle of the coxa.

THE METATHORAX.

The connection of the metathorax to the mesothorax has already been noted. It is weakly joined to the abdomen, not only because it is connected to the abdomen by a membrane, but also because the first segment of the latter is partly membranous itself. It is similar to the mesothorax in general make-up, especially in the number of sclerites.

The *notum* (pl. LVII, fig. 9), as in the mesothorax, is composed of four sclerites—the prescutum, scutum, scutellum, and postscutellum. The *prescutum* is peculiar in that it is entirely internal, extending directly into the body cavity and lying at right angles to the scutum. It is a very large, bilobed sclerite, heavily chitinized, and is used for attachment of large bundles of muscles.

The *scutum* is the large, heavily chitinized sclerite found on the dorsal surface of this segment. It is rectangular in shape and its width is one and one-half times its length. Along its median line is a heavy, black line which is the external indication of an infolding of chitin, which also serves for muscle attachment.

The *scutellum* of the metathorax is much reduced, consisting of a small, median portion, which is produced laterad into a narrow band. The latter is directly connected with the anal margin of the wing.

The *postscutellum* is a flat chitinous sclerite, which is extremely narrow mesad, but which expands laterad into two tapering side processes. The cephalic margin of the postscutellum is attached to the anterior margin of the scutellum, which is the suture separating the scutum from the scutellum. The diagonal, lateral angle of the postscutellum is directly attached to the margin of the epimeron and no postalare is present, as in the *Cicada*.

The *pleuron* (pl. LVII, fig. 8) is very well developed, being by far the largest part of the metathorax. It not only occupies all the pleural regions, but extends into the dorsal and ventral regions and forms a major part of the metathorax.

A distinct *pleural* suture extends the entire length of the pleuron.

The episternum is an undivided sclerite, although on its caudal end is the beginning of a suture which runs parallel to the pleural suture. The episternum is the largest of the pleural sclerites, occupying the ventral half of the pleuron, the lateral third of the venter, and the laterocephalic angle of the dorsum, where it curves around the wing process.

The *epimeron* is likewise a large sclerite, but it is found chiefly on the lateral and dorsal parts of the segment. It occupies the dorsal half of the pleuron and lateral part of the dorsum, where mesad it touches the lateral margins of the scutum and postscutellum (pl. LVII, fig. 9). The lateral extensions of the metascutellum, which are joined to the axillary cord of the wing, lie on top of the epimeron. From a lateral view (pl. LVII, fig. 8) the indentation made by the wing process can easily be seen. Ventrally the epimeron shows as a plate forming the caudal boundary of the episternum. A suture divides the sclerite into an upper and lower portion. A flaplike process is present in the lower epimeron of Lepyronia, which is probably similar to that found by Taylor (1918) in an *Aphrophora*.

The *sternum* (pl. LVII, fig. 11) is small when compared to the sternum of the mesothorax. The *presternum* of this segment is partly membranous, with a weak deposition of chitin in its median and caudal portions. It is roughly crescentic in shape.

The *sternum* is entirely membranous and is divided into two distinct halves by a very narrow, chitinous band, which appears to be a caudal extension of the chitinous part of the presternum.

The *sternellum* appears to be a narrow, chitinous rod extending between the epimera, with which it appears to be fused. It is located beneath the posterior coxæ, and for this reason is more easily seen from a dorsal view than from a ventral view (pl. LVI, fig. 7).

The *trochantin* is a knoblike structure terminating the caudal end of the pleuron. It is termed by Taylor (1918) the meron, or at least he assigns this term to a similar structure in an *Aphrophora*, but does not account for a trochantin.

THE WINGS.

The *forewing* (pl. LVIII, fig. 4) of *Lepyronia* is thick, opaque and rather tough. Its entire surface is broken up into fine reticulations and is covered by a grayish pubescence, similar to that of the head. These conditions, together with the even coloring of the wing, entirely obscure the venation in uncleared specimens. It was only in half-bleached specimens that the veins could be traced at all. The venation of both wings here studied was found to be almost identical with the venation of the same species as described by Metcalf (1917).

Costa is a single, unbranched vein which forms the costal border.

Subcosta is so closely related to radius, at least distally, that it only appears as a definite vein along the center of its course, where it is widely separated from radius and thus forms an elongate, oval cell. *Radius* has three branches, which are R_1 and R_{2+3} and R_{4+5}. *Media* is unbranched and is closely connected with cubitus, at least at its base. *Cubitus* is two-branched. There are three *anal* veins present, the first one of which is united with cubitus 2 on the margin of the wing.

In the *hindwing* the veins show up very plainly, being brown in color and quite thick, while the cells of the wing are membranous. *Radius* is two-branched, the branches being R_{2+3} and R_{4+5}. *Media* is unbranched and *cubitus* is two-branched. Three *anal veins* are likewise present in this wing, the first one being closely connected with cubitus basally, while the third one is branched.

Part of the anterior margin of the posterior wing is produced into a triangular projection whose outer margin bears from four to six stout spines or hooks. Also on the ental surface of the tegmina just in front of subcosta is a little elevated keel. According to Hansen (1890) these hooks and keel are complementary structures and contribute to the steadiness of the wings.

THE LEGS.

The three pairs of legs have a general similarity with respect to position on the body, development, relative size, and number of segments. When in action the front legs usually point forward and the two last pairs point backward (pl. LV, fig. 1), but when at rest they are drawn up under the sloping tegmina (pl. LV, fig. 4) so that they are invisible from above. The hind pair is the longest and the other two are about equal in length. All are well developed as a result of their jumping habit. The number of segments is the same in each, consisting of coxa, trochanter, femur, tibia and a three-segmented tarsus. They are blackish brown in color, especially the proximal segments, but gradually grow lighter toward the distal ones. All three pairs are covered by a fine pubescence.

The *coxa* (pl. LVIII, fig. 3) of the front leg is stout and thick in comparison with the other segments of the leg, but it is not as large as the coxæ of the other two pairs. It is smooth and about equal in length and width. It is almost cylindrical in shape, although its proximal end broadens out transversely and thus gives the effect of a flattened plate. The two anterior coxæ are separated from each other by the width of the beak, which fits down between them.

The *trochanter* is a small elbow-shaped piece which is attached to the ventromesal angle of the coxa. It is slightly constricted at its cephalic end and is about one-fourth the size of the coxa.

The *femur* is a cylindrical-shaped segment which is somewhat swollen at the proximal end, but gradually becomes narrow distad. It is the stoutest of the leg segments outside of the coxa. The trochanter is attached to its mediocephalic angle by a diagonal line of connection. Its distal end bears a small groove into which the tibia is inserted, while the lateral margins of the groove expand into a platelike structure on either side of the tibia for the purpose of strengthening the joint.

The *tibia* resembles the femur in general shape. It is cylindrical, smooth, and approximately the same length as the femur, but its width is only half that of the femur. The proximal end, which fits into the grove of the femur, is elbowed. There are no spines on the front tibia.

The *tarsus* is three-segmented. The first two segments are about equal in length, triangular in shape and larger ventrally than dorsally.

The tarsus is terminated by two equal, heavily chitinized *claws* (pl. LVIII, figs. 6 and 9). The claws are broad at the base and gradually taper to an obtuse blunt point. The pulvillus or empodium, according to Hansen (1890), is very conspicuous and greatly extended. On its dorsal surface it bears a large, bilobed, chitinous plate, and just below this a bristle (pl. LVIII, fig. 6). On the ventral side (pl. LVIII, fig. 9) are two narrow, longitudinal bands which run parallel to the margins of the claws. These bands and part of the claws appear to be attached to the third segment of the tarsus by a lightly chitinized band or stalk.

The *middle legs* (pl. LVIII, fig. 2) are attached directly to the sternum by the broad, transverse margins of the coxæ. The trochantin of the mesothorax is much smaller than that of the prothorax and is situated on the extreme laterocephalic angle of the coxa just above the meracanthus. The median leg, in most respects, is similar to the fore leg, being almost identical in size and shape of segments with the exception of the coxæ. The latter are somewhat larger than the anterior coxæ and their median margins are almost contiguous. They have on their lateral margins a large, flattened process or *meracanthus* which is not found on the other four legs.

The *posterior coxæ* (pl. LVIII, fig. 8) are more broadly attached to the body than even the intermediate coxæ are, since they extend

across the entire width of the sternum. The sternellum and the first segment of the abdomen is completely hidden by them, and part of the second and third segments of the latter are also covered. They are contiguous along their inner margins, which fact, together with their broad, basal attachment, gives them the appearance of great rigidity. In shape they are roughly rectangular with their laterocephalic angle somewhat extended.

The *trochanter* of the hind leg is similar to those of the first two pairs of legs, in that it is an elbow-shaped segment and of the same size as the others.

The *femur* is a smooth, cylindrical-shaped segment, diagonally attached to the trochanter. On its proximal lateroventral margin is an oblique protuberance (pl. LVIII, fig. 7), which, according to Hansen (1890), occurs in all Cercopidæ, but in no other Homoptera. The knee joint is strengthened, as in the two anterior pairs of legs, by the groove and side plates of the femur, which are very prominent and show plainly in figures 7 and 8 (pl. LVIII).

The *tibia* of the hind leg is greatly lengthened. Basally it is quite narrow, but broadens to twice its width distad. Along its outer margin it bears two large, thick spurs, which are of taxonomic importance in distinguishing the family. The second of these is approximately twice the size of the first in both length and thickness. The distal end of the tibia bears two rows of thick, sharply pointed spines. The average number of spines, after counting twenty specimens, was seven on the top row and eight on the lower. These spines are shiny black at the tip and from between each two of them arises a long, silken hair which is twice the length of the spines.

The *tarsus* is composed of three segments, the first two of which are similar in shape to the tibia, being narrow at the base and spatulate at the tip. They also bear a row of spines on their distal ends, which are like those of the tibia in shape and color but which are only half as large. The average number of spines on the first segment is seven, and on the second, nine to eleven. The distal segment of the tarsus is swollen but not spatulate.

THE ABDOMEN.

The number of segments in both the male and female abdomens is eleven plus a telson. From a dorsal and lateral view the abdomen is not visible, since the sloping tegmina completely hide it. It can, of course, be easily seen from a ventral view, but owing to the enlarged hind legs, especially the coxæ, and the fact that its segments

are more or less telescoped, few details of structure can be made out without first removing the legs. Its color is like that of the rest of the body, and is uniform throughout with the exception of the sutures, which are somewhat lighter in color, indicating their membranous nature. The abdomen is very wide at its base, but tapers to a pointed apex, due to the fact that the segments decrease in size from front to rear. Each segment overlaps the following one, which produces a telescopic effect. The segments are divided into three general regions—tergum, pleuron, and sternum. The tergum occupies all the dorsal region, while the pleuron and sternum are to be found on the ventral surface.

The ventral, dorsal and lateral views of the male abdomen are shown on plate LIX, figs. 1, 2 and 3. The first segment was difficult to find, owing to its irregularity of shape and its half-membranous structure. The *tergum* is partly membranous and partly chitinized, although the chitin is very weak even where it is present. Along its cephalic margin is a transverse, chitinous band, which mesad is very narrow but which is broadly expanded laterad. This anterior band is separated from a similar posterior, chitinous band by a strip of membrane. The first tergum appears to be attached to the postscutellum by a membrane.

The *pleuron* (pl. LIX, fig. 2) of the first segment is greatly reduced and occupies a peculiar position on the abdomen. It is a small, triangular, heavily chitinized plate lying on the laterocaudal angles of the tergum. This is the only pleuron visible from the dorsal view of the abdomen, but is easily recognized as such by the distinct spiracle located near its upper margin.

The *sternum* is also greatly modified. Its anterior margin is produced into a flaplike structure which bends forward on the remainder of the segment, due to pressure from the thorax (dotted line, pl. LIX, fig. 1). The lateral parts of the first sternum are membranous and deeply depressed where the chitinous angles of the thorax fit down against it.

The *tergum* of the second segment is entirely chitinous, not extending across the entire dorsal surface of the abdomen, but with its lateral, rounded margins extending cephalad and bounded by the cephalad-projecting corner of the third tergum.

The *pleuron* (pl. LIX, fig. 1) of the second segment is of the same shape as the pleuron of the first, but is somewhat smaller. The relation of the two can be seen from a lateral view (pl. LIX, fig. 3). The two bases of the triangles adjoin each other, while the apices

extend dorsad and ventrad, respectively. The spiracle of this pleuron is difficult to locate, since it lies near the mesal margin of the pleuron and is visible only from a ventral view of the abdomen.

The *sternum* of the second segment is an elongate, narrow, chitinous band which tapers laterad to a fine point. Superficially this is taken as the first sternite, since the latter, because of its membranous condition, usually is pulled off with the thorax when it is removed.

The third to eighth segments are practically all alike, being ringlike, in form and differing only in size. The terga are heavily chitinized and occupy the entire dorsal surface. The pleura are roughly rectangular, somewhat inflated, and with both lateral and median angles slightly rounding. The pleura are wider than either the sterna or terga. The sterna are elongate, rectangular plates forming the real ventral wall of the abdomen.

The *pygofer* or *gonomere* is the modified ninth tergite, which is a rounded, bulblike structure, bearing on its dorsal surface the anal tube. The ninth sternite forms the plate beneath the genital apparatus, and is called by Crampton (1922) the *hypandrium* (pl. LIX, fig. 1). These make the ninth segment a very prominent segment of the abdomen.

The anal tube (pl. LIX, fig. 2), as was stated above, is situated on the dorsal surface of the abdomen, apparently fitting into a circular depression and connected to the pygofer by a membrane. It is composed of two segments, which represent the tenth and eleventh abdominal rings or uromeres. The tenth uromere is by far the larger and is termed by Crampton the *proctiger*. The eleventh segment bears the telson, which is triangular in shape and is divided in the middle into two distinct halves by the anus.

The female abdomen (pl. LIX, figs. 4, 5, and 6) is similar to that of the male in most details. The first tergum is both membranous and chitinous, but differs from the male in that there is only a single, irregular band of chitin along its cephalic margin instead of two. The first sternum and pleuron are much the same as in the male.

The second to seventh segments of the female show little difference from those of the male. The eighth sternum, however, has been slightly modified to admit the ovipositor. It is divided into two distinct halves by the bases of the ovipositor valves, which extend cephalad until they reach the caudal margin of the seventh sternum. Each plate of this sternum is an inverted right-angled triangle,

with its caudal margin somewhat curving. The eighth pleura and tergum appear quite normal.

The ninth segment, or *pygofer*, is greatly enlarged and inflated, even more so than in the male. The anal tube is borne on its dorsal surface, but occupies a more caudal position than in the male. For this reason the pygofer is more bulblike, extending around on the ventral surface, and thus making up a large share of the posterior end of the female abdomen. Its median margins do not meet on the ventral surface, since the valves of the ovipositor extend between them. There appears to be no ninth pleuron externally, as its position is occupied by the tergum, but a remnant of the ninth sternum (pl. LIX, fig. 6) is to be seen, forming the two slender basal parts of the dorsal valves of the ovipositor.

The *anal tube*, as in the male, consists of the tenth and eleventh segments plus the triangular telson, and is attached to the posterior region of the pygofer by a membrane which fits into a circular opening. The eleventh segment is greatly reduced, however, being about one-eighth as long as the same segment of the male.

THE MALE GENITALIA.

From an external view of the abdomen part of the so-called "internal genitalia," as well as the "external genitalia," are visible. The organs usually included as "internal genitalia" are the paired styles, the œdagus and the connective. The parts which are exposed are the apical two-thirds of the styles. These are plainly visible on the dorsal surface of the abdomen and have no protective covering of any sort.

The basal parts of the styles, the connective, and the œdagus are situated in a genital or terminal chamber formed by the pygofer and anal tube. Since this chamber is really not closed, but is open beneath the anal tube, these parts are not really internal, but are only designated as such for convenience.

There is no indication of the presence of the diaphragm, which Gifford (1922) found to be present in the genital chamber of the Delphacidæ. In fact, the entire genital chamber of these insects varies considerably from that of *Lepyronia*.

The *genital plates* (pl. LIX, fig. 1) are two valvelike processes on the ventral surface of the abdomen. They have been given various names, such as hypovalvæ, ventral plates, and genital plates. They are large, prominent flat plates, occupying most of the apical end of the abdomen, and are broad at the base but taper to a pointed

apex. These plates, as is shown from nymphal development, arise from a genital area on the ninth segment. They are indistinctly fused with the caudoventral margin of the pygofer or with the area termed by Crampton (1922) the *hypandrium*. The lateral margins of the hypandrium are indistinguishably united with the lateral margins of the pygofer. The plates are separated along their mesal lines by a long cleft which extends nearly to the eighth sternite.

The *styles* (pl. LXI, figs. 7 and 8) have been given various names, such as gonistyli, claspers, or genital styli. They are very irregular in shape. At their cephalic end they taper to a very slender point, while their caudal end is truncate. The widest part of the style is at the point of attachment to the connective. Just cephalad and caudad of this point it is constricted, but it broadens out again caudad of the latter constriction into a second enlarged part. At this particular point on the dorsal surface of each clasper arises a prominent hook, the tip of which extends in a cephalomesal direction. From a lateral view of the genitalia (pl. LXI, fig. 5) the nature of the relation of this hook to the style can best be seen. Just distad of each hook is a slight notch in the clasper. The apex of the organ bends mesad in a distinct curve. The styli are connected to the ventral wall of the pygofer at about the laterocephalic angles of the hypandrium, and they extend directly caudad. They are fastened to the connective only at its extreme lateral tip by a very narrow band of membrane, although the connection would seem to be much greater, since from a ventral view of the organs the connective covers a large part of the claspers on each side. The union of the two can be seen from a ventral and lateral view of the genitalia. The styli are fairly well chitinized, but not enough to keep them from being flexible. Their function is that of clasping or interlocking during copulation.

The *connective* (pl. LXI, figs. 7 and 8) is a flat chitinous plate, roughly triangular in shape, which extends between the two claspers and is attached to the latter at about the base of their anterior third. The lateral margins are produced into a slender recurved hook which extends cephalad and whose inner margin is attached to the styli. The broad basal part of the connective is chitinized, but the apical region is entirely membranous. Bordering this membrane on the sides are two slender, chitinous rods which extend caudad, where their tapering points are attached to the ventral surface of the base of the œdagus. It has been suggested by Doctor Lawson that the connective may possibly represent the tenth sternite, since its origin has not otherwise been accounted for.

The *œdagus* (pl. LXI, figs. 7 and 8) is a term applied to the structure containing the penis. It has been called by other writers the penis sheath, or merely the penis. It too arises from a genital area on the ninth segment. In texture the œdagus is quite heavily chitinized and is very smooth and shiny. Basally the œdagus is club-shaped, flattened dorsoventrally, and gradually narrowing to a long, slender, chitinous tube which extends cephalad to a point beyond the anterior tips of the styles. Its apex is broadened into a flat plate, whose laterocaudal angles bear two longer, slender, tapering hooks, the penis hooks, which extend directly caudad.

From the center of the broad plate there appears to arise a slender, membranous tube, which also projects caudad, parallel with the penis hooks. At the apex of the tube is a circular opening or *gonopore*. There is also another circular opening at the base of the œdagus, which is probably the opening of the ejaculatory duct. The flat apical part of the œdagus lies directly beneath the proctiger or tenth uromere. The latter has on its lateral margins a small hooklike structure (pl. LIX, fig. 2) which seems to fit down around the œdagus and which may correspond to the *surgonopods* of Crampton (1922). The œdagus is protective in function, since it serves to protect the delicate penis.

THE FEMALE GENITALIA.

On the female the genitalia consist of three pairs of appendages, which collectively are often spoken of as the ovipositor. More properly speaking, however, the ovipositor is made up of only two pairs of valves, the ventral and dorsal, and the lateral pair form a sheath around them. The eighth sternum of the abdomen, as was noted above, is divided into two distinct plates by the processes of the ovipositor, while the ninth sternite is represented by two small rectangular sclerites to which the lateral valves of the ovipositor are attached.

The *lateral valves* (pl. LX, fig. 3) have been given other names in the literature, such as outer valves, posterior processes, or ovipositor sheaths. They are the outermost of the three pairs and fold around the inner pairs as is shown in figure 1. They arise from a genital area on the ninth segment and are attached in the adult to the vestigial parts of the ninth sternite. The attachment is broad and transverse to the caudal end of the sternite. Each lateral valve is a broad, spoon-shaped appendage which is deeply concave on its inner surface, so that half of it shows from a ventral view of the genitalia (pl. LX, fig. 1) and half from a dorsal view (fig. 6).

Its ventral basal part appears to be entirely membranous. The pygofers fit very snugly around the lateral valves, but are not attached to them. These valves are tough, fairly well chitinized and with their outer surfaces pubescent. Their ventral surfaces are plainly visible from an external view.

The *ventral valves* (pl. LX, fig. 2) are the middle pair of valves. Other names which have been applied to them are middle valves, anterior processes or ventral processes. They arise from the eighth sternite, to which they are still attached in the adult. Each valve is fastened to its half of the eighth sternite by a membrane which connects the mesal corner of the sternite and the cephalomedian angle of the valve. They are flat rather broad processes, which taper to a fine point and which bear a broad notch near the base of the dorsal margin. The ventral valves enfold the dorsal valves and the ventral and dorsal valves of each side are fastened together by a tongue-and-groove connection. The ventral valves are not as heavily chitinized as either the lateral or dorsal ones.

The *dorsal valves* (pl. LX, fig. 5), which have also been called inner valves or median valves, are the innermost of the three pairs of valves, and make up the ovipositor proper. They arise from a genital area on the ninth segment of the nymph and are still attached in the adult stage to the cephalic end of the ninth sternite. Each valve is a flat, bladelike structure, broader at the base, but tapering to a pointed apex. The basal half of their inner or dorsal margins are united and the free apical portions bear teeth. These teeth are small, sharply pointed, with broad, shallow indentations between them, and are about fifteen in number. The teeth are used as a saw with which to cut the plant tissue. The ventral margins of these valves bear heavily chitinized grooves into which the tongues of the ventral valves are inserted.

Extending along the approximate median line of the ventral valves is a slender, chitinous rodlike structure. Superficially this appears to be a chitinous thickening of the valve, but when it is traced cephalad it is not found to be attached basally to the sclerite to which the valve is fastened. The sclerite to which it is fastened is a small, triangular plate (pl. LX, fig. 4), which is attached to the lateral margins of the ninth sternite, the cephalic margin of the pygofer, and normally lies hidden beneath the eighth sternite. It probably represents the ninth pleurite.

DEVELOPMENT OF THE GENITALIA.

As early as the third instar the nymphal genitalia are not only distinctly visible, but furnish reliable characters by which to distinguish the sexes. They cannot be clearly made out, however, in the first two stages without careful study.

The *male genitalia* arise from a genital area on the ninth abdominal segment. In the first and second instars only one pair of valves is present. Superficially they appear as two opaque, elongate, elevated ridges which occupy the major part of the ninth sternite. Closer examination reveals that they are two chitinous pockets (pl. LXI, fig. 1), which are separated from each other by a median chitinous band and which produce the genital appendages of the next nymphal stage. The pockets are attached to the caudal border of the genital area with their apices directed caudad and are rounded at the tip. The genital area is comparatively short and extends cephalad under the caudal margin of the eighth sternum, due to the telescopic arrangement of the abdominal segments, so that at first glance the pockets appear to arise from the eighth sternite. This pair of pockets produces the genital plates of the adult.

In the second instar (fig. 2) the pockets have increased slightly in size, but are similar in other respects to those of the first.

In the third instar there is a noticeable increase in size of the genital area. The pockets of the genital plates have become broader but are not so deeply bilobed. In addition to the one pair of pockets there is now present another pair, which are located dorsad and slightly caudad of the first pair. These produce the genital styles or claspers of the adult insect.

In the fourth instar the genital area has become large and prominent. There is a great increase in the size of the dorsal pockets, which have now become twice as long as the ventral pair. Both are rounded at the tip.

In the fifth instar still greater changes have taken place. The ventral pockets have become greatly elongated and their apices have diverged slightly. The genital area has lengthened between the ventral plates and the dorsal plates so that the former do not extend over the latter at all. The dorsal pockets have also diverged considerably, and between them can be seen the apices of another pair of pockets. These median pockets are only half as long as the pockets of the genital styles, are rounded at the apex and produce the œdagus of the adult.

The *female genitalia* in the first and second instars (pl. LXII, figs. 1 and 2) are very difficult to distinguish from those of the male. There are two pairs of valves present, but since they are practically of the same color and texture and one pair is placed upon the other, they appear as a single pair and therefore resemble the male. The first pair are small, rounded at the tip and project from the eighth sternite as a caudal extension of the latter. Thus it is clearly evident that they arise from the eighth sternite, whereas in the male the posterior margin of the eighth sternite can be seen to lie on top of the first pair of pockets. This pair of pockets develops into the ventral valves of the adult ovipositor. The second pair of pockets, which produce the dorsal valves of the ovipositor, project from above the first pair and are twice as long as the first pair. Together they occupy about one-half the length of the ninth sternite.

In the third instar the ventral pockets have increased both in width and length. Here they are more easily seen to be attached to the eighth sternite. The dorsal pockets have become greatly enlarged. They are entirely separated from the ventral pockets, occupying about the center of the ninth sternite. The lateral pockets are present in the third instar for the first time. They lie laterad of the dorsal pockets, are somewhat narrower, although much longer, and curve slightly mesad. They develop into the lateral valves of the adult.

In the fourth instar the ventral plates are greatly enlarged, so that their apices reach the base of the dorsal valves. The dorsal valves are larger than in the preceding instars, but are still the smallest of the three pairs. The lateral pockets, which are the largest pair of pockets, have their apices projecting much farther caudad than the dorsal valves and their bases reaching cephalad almost to the eighth sternum.

In the fifth instar the pockets are very prominent. The ventral pockets are broad at the base, extending the entire width of the sternum and taper gradually to narrowly rounded apices. The dorsal valves are somewhat the shape of the ventral and are entirely covered by the latter. Their bases, however, do not reach to the eighth sternum. The lateral pockets are fingerlike structures with their bases partly covered by the ventral valves and are still slightly longer than either of the other two pairs. The genital area is very prominent and has been pushed cephalad until it occupies all the eighth sternum, and even extends into the seventh, where the indica-

tion of the division of the eighth sternum in the adult is shown by the division of the nymphal integument.

From the foregoing studies it appears that the male and female genitalia are not strictly homologous, since the three pairs of valves in the male arise from a genital area on the ninth segment, while in the female one pair comes from the eighth and two from the ninth. This agrees with Kornhauser's (1919) work on a membracid and Hackman's (1923) work on a cicadellid. Kershaw and Muir (1922) in their studies of a cercopid, *Philænus leucophthalmus,* make the statement that the gonopophyses of the male arise in exactly the same place as in the female. This conclusion appears to be drawn from a study of the fourth and fifth instars only, which are not sufficient to give a true interpretation of the origin of these organs.

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PLATE LIV.

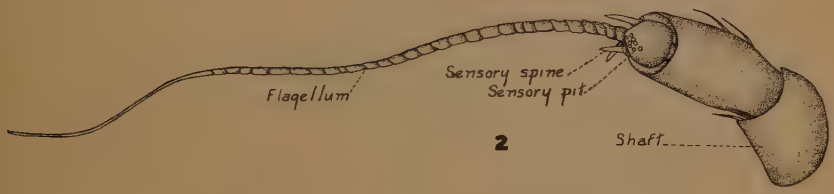
1. Egg.
2. First instar.
3. Second instar.
4. Fifth instar.
5. Third instar.
6. Fourth instar.

PLATE LIV.

PLATE LV.

1. Lateral view of adult.
2. Antenna, highly magnified.
3. Dorsal view of adult.
4. Ventral view of adult.

PLATE LV.



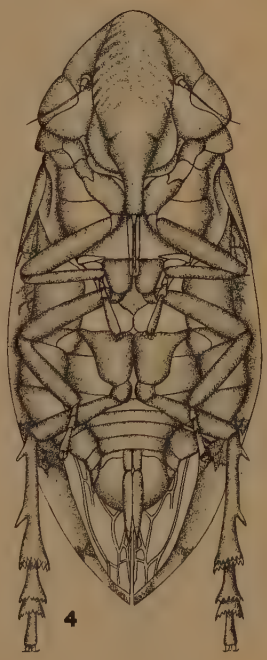


PLATE LVI.

1. Dorsal view of head.
2. Ventral view of head.
3. Dorsal view of head with vertex removed, showing the tentorium.
4. Tips of mandible and maxilla, highly magnified.
5. Lateral view of head.
6. Lateral view of thorax.
7. Dorsal view of mesothorax and metathorax.
8. Ventral view of mesothorax and metathorax.

PLATE LVI.

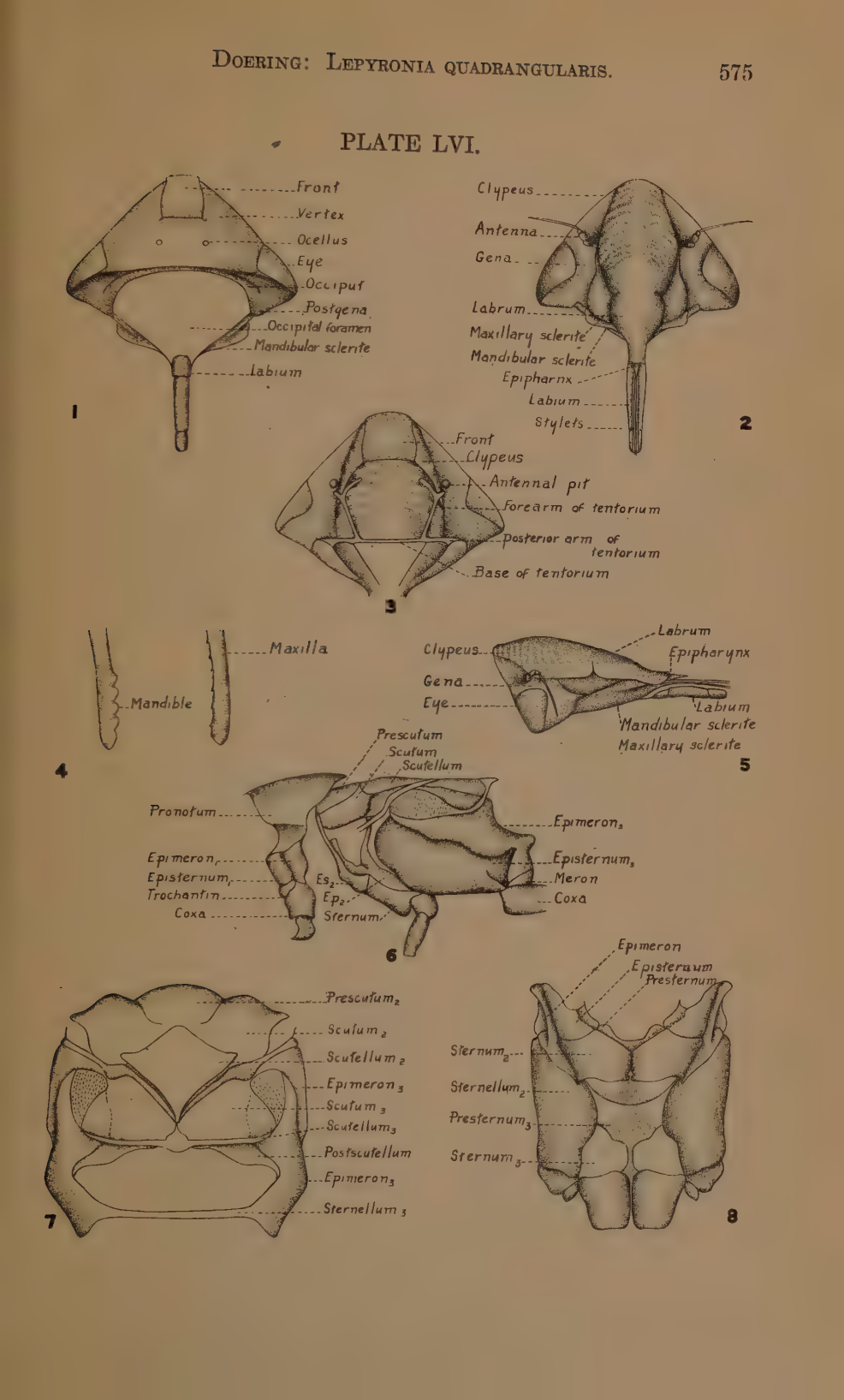
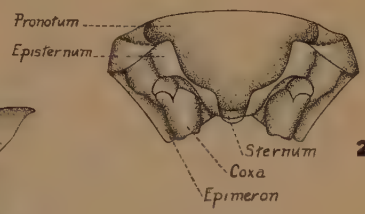

Front
Vertex
Ocellus
Eye
Occiput
Postgena
Occipital foramen
Mandibular sclerite
Labium
1
Clypeus
Antenna
Gena
Labrum
Maxillary sclerite
Mandibular sclerite
Epipharnx
Labium
Stylets
2
Front
Clypeus
Antennal pit
Forearm of tentorium
Posterior arm of tentorium
Base of tentorium
3
Maxilla
Mandible
4
Clypeus
Gena
Eye
Labrum
Epipharynx
Labium
Mandibular sclerite
Maxillary sclerite
5
Prescutum
Scutum
Scutellum
Pronotum
Epimeron₂
Epimeron₁
Episternum₁
Trochantin
Coxa
Es₂
Ep₂
Sternum
Episternum₂
Meron
Coxa
6
Prescutum₂
Scutum₂
Scutellum₂
Epimeron₃
Scutum₃
Scutellum₃
Postscutellum
Epimeron₃
Sternellum₃
7
Epimeron
Episternum
Presternum
Sternum₂
Sternellum₂
Presternum₃
Sternum₃
8

PLATE LVII.

1. Dorsal view of pronotum.
2. Ventral view of prothorax.
3. Lateral view of prothorax.
4. Caudal view of prothorax.
5. Cephalic view of prothorax.
6. Lateral view of mesothorax.
7. Dorsal view of mesothorax, showing wing attachments.
8. Lateral view of metathorax.
9. Dorsal view of metathorax.
10. Ventral view of mesothorax.
11. Ventral view of metathorax.

PLATE LVII.

1



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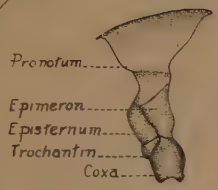

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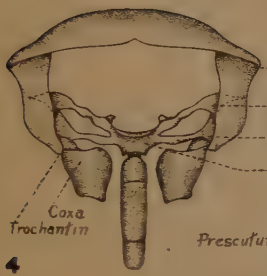

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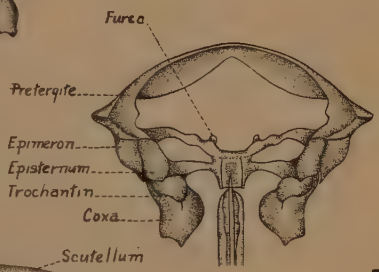

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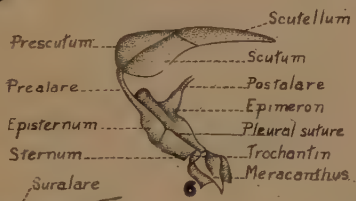

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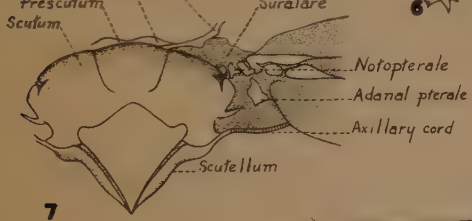

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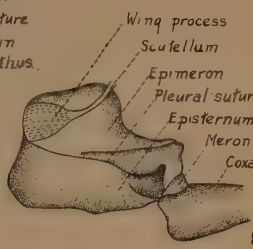

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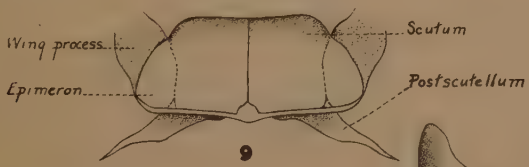

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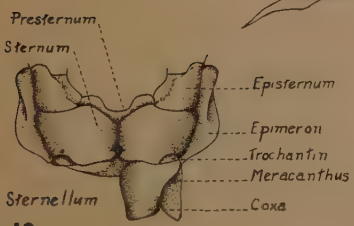

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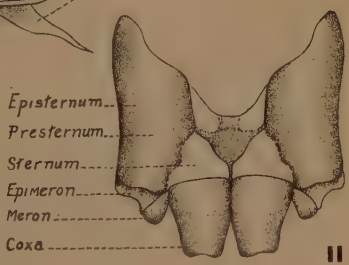


11

PLATE LVIII.

1. Forewing, showing venation.
2. Mesothoracic leg.
3. Fore leg.
4. Fore wing, showing color pattern.
5. Hind wing.
6. Dorsal view of tarsal claws.
7. Hind femur, showing flaplike process.
8. Metathoracic leg.
9. Ventral view of tarsal claws.

PLATE LVIII.

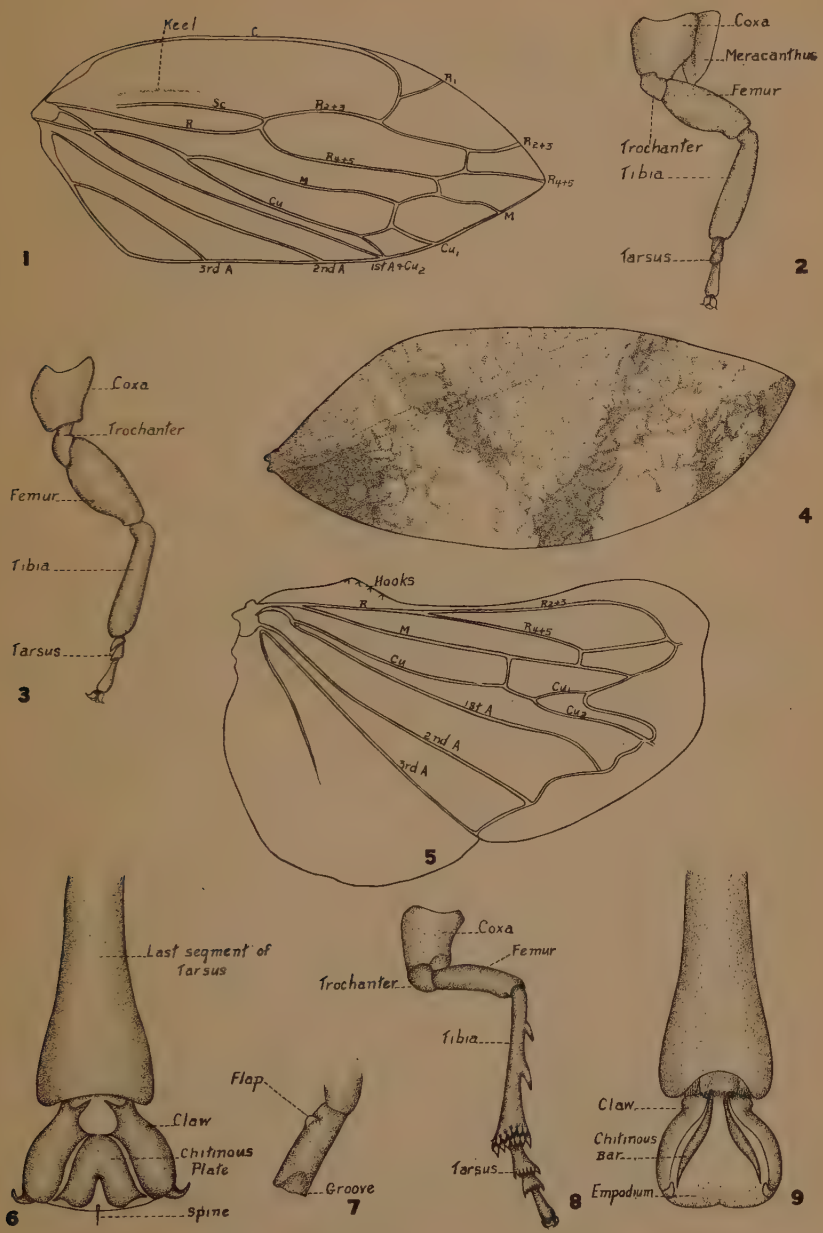
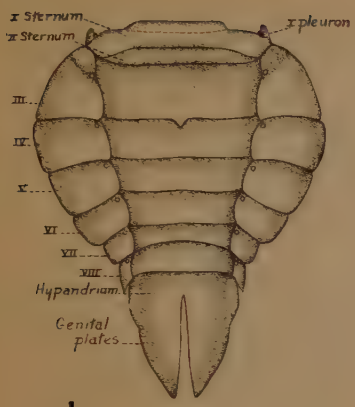

Keel
C
Sc
R
R_1
R_{2+3}
R_{2+3}
R_{4+5}
R_{4+5}
M
M
Cu
Cu_1
3rd A
2nd A
1st A+Cu_2
1
Coxa
Meracanthus
Femur
Trochanter
Tibia
Tarsus
2
Coxa
Trochanter
Femur
Tibia
Tarsus
3
4
Hooks
R
R_{2+3}
M
R_{4+5}
Cu
Cu_1
Cu_2
1st A
2nd A
3rd A
5
Last segment of Tarsus
Claw
Chitinous Plate
Spine
6
Flap
Groove
7
Coxa
Femur
Trochanter
Tibia
Tarsus
8
Claw
Chitinous Bar
Empodium
9

PLATE LIX.

1. Ventral view of male abdomen.
2. Dorsal view of male abdomen.
3. Lateral view of male abdomen.
4. Lateral view of female abdomen.
5. Dorsal view of female abdomen.
6. Ventral view of female abdomen.

PLATE LIX.



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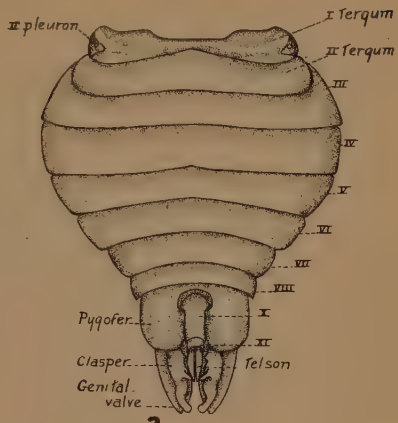

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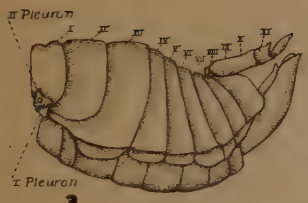

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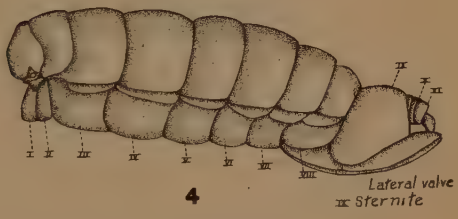

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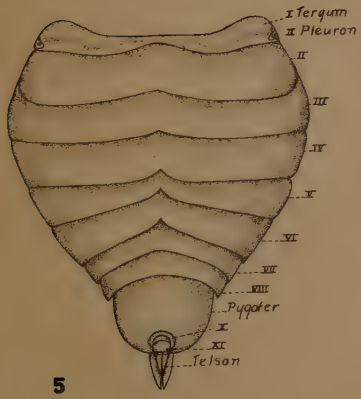

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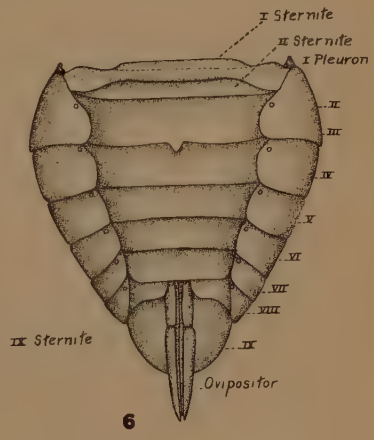
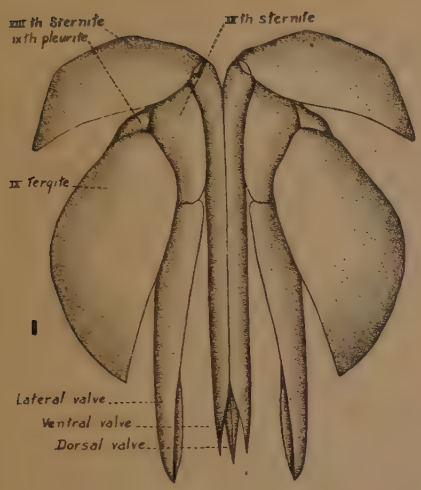


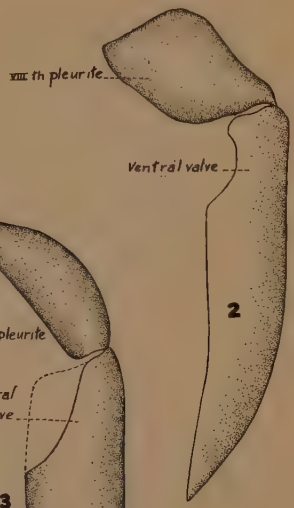
6

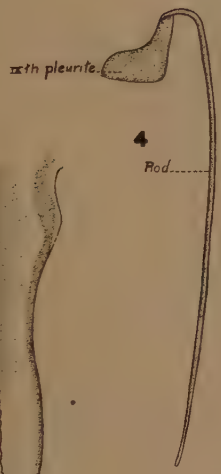
PLATE LX.

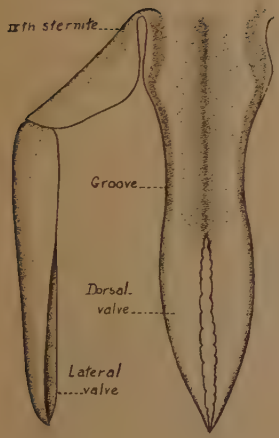
1. Ventral view of female genitalia.
2. Lateral view of ventral valve.
3. Lateral view of lateral valve.
4. Rodlike structure found on ventral valve.
5. Ventral view of dorsal valves and lateral valve.
6. Dorsal view of female genitalia.

PLATE LX.


VIII th Sternite
IX th pleurite
IX th sternite
IX tergite
1
Lateral valve
Ventral valve
Dorsal valve


VIII th pleurite
Ventral valve
2
IX th pleurite
Lateral valve
3


IX th pleurite
4
Rod


IX th sternite
Groove
Dorsal valve
Lateral valve
5

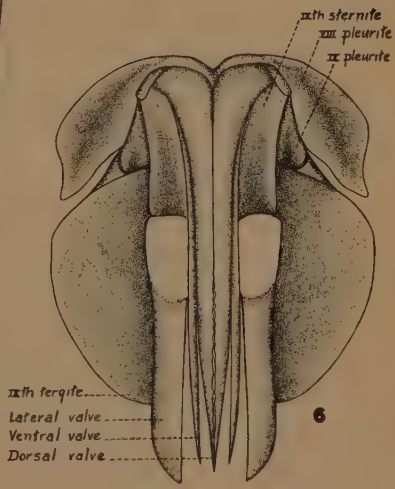
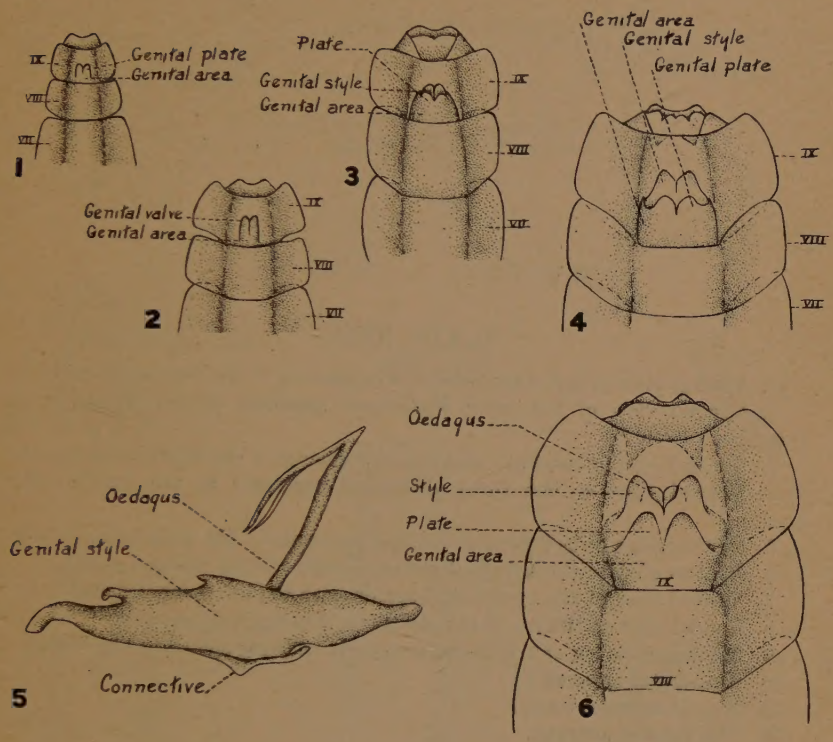

IX th sternite
VIII pleurite
IX pleurite
IX th tergite
Lateral valve
Ventral valve
Dorsal valve
6

PLATE LXI.

1. Ventral view of the last three abdominal segments in first-instar male.
2. Ventral view of last three abdominal segments of second-instar male.
3. Ventral view of last three abdominal segments of third-instar male.
4. Ventral view of last three abdominal segments of fourth-instar male.
5. Lateral view of adult male genitalia.
6. Ventral view of last three abdominal segments of fifth-instar male.
7. Ventral view of adult male genitalia.
8. Dorsal view of adult male genitalia.

PLATE LXI.


Genital plate
Genital area
IX
VIII
VII
1
Genital valve
Genital area
2
Plate
Genital style
Genital area
3
Genital area
Genital style
Genital plate
4
Oedagus
Genital style
Connective
5
Oedagus
Style
Plate
Genital area
6

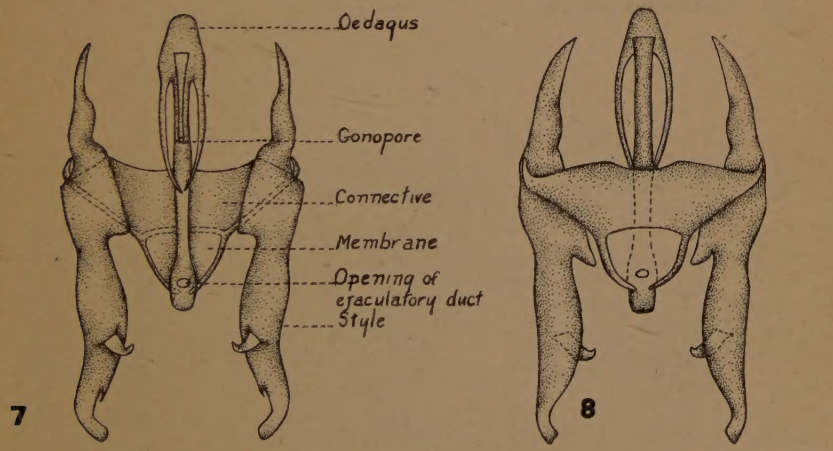
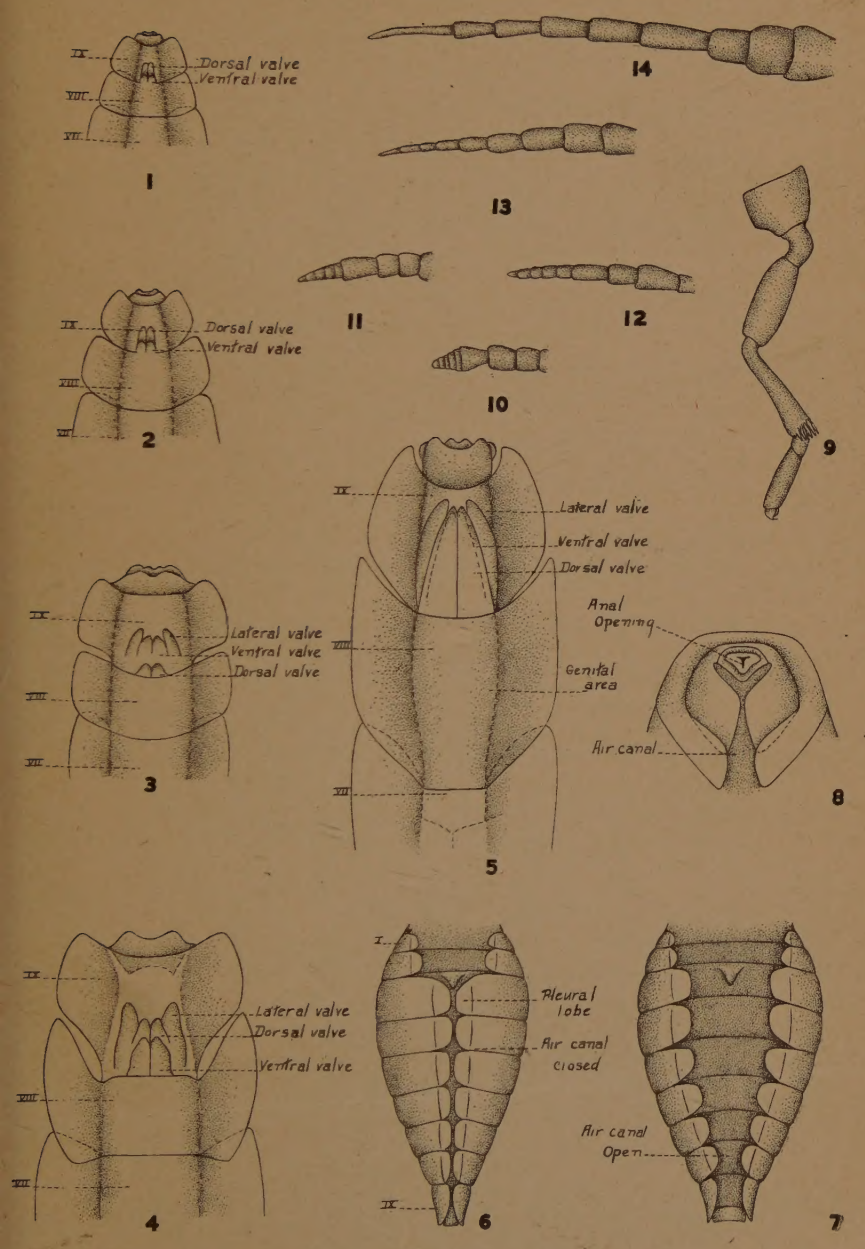

Oedagus
Gonopore
Connective
Membrane
Opening of ejaculatory duct
Style
7
8

PLATE LXII.

1. Ventral view of last three abdominal segments of the first-instar male.
2. Ventral view of last three abdominal segments of the second-instar female.
3. Ventral view of last three abdominal segments of the third-instar female.
4. Ventral view of last three abdominal segments of the fourth-instar female.
5. Ventral view of last three abdominal segments of the fifth-instar female.
6. Ventral view of the nymphal abdomen with the air channel closed.
7. Ventral view of the nymphal abdomen with the air channel open.
8. Caudal view of the tip of the abdomen, showing anal opening.
9. Mesothoracic leg of a fifth-instar nymph, showing spines on the femur.
10. First-instar antenna.
11. Second-instar antenna.
12. Third-instar antenna.
13. Fourth-instar antenna.
14. Fifth-instar antenna.

PLATE LXII.


IX
VIII
VII
Dorsal valve
Ventral valve
1
14
13
11
12
10
9
2
Lateral valve
Ventral valve
Dorsal valve
3
5
Anal Opening
Genital area
Air canal
8
4
6
Pleural lobe
Air canal closed
Air canal Open
7